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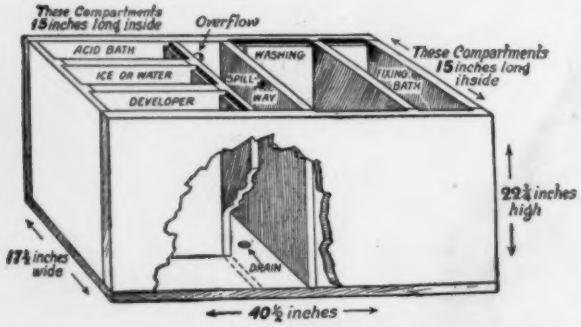

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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REPORT OF A CASE OF THYROID METABOLISM

By C. W. SCHWARTZ, Ph.B., M.D.

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THE following case is reported not so much because it offers anything new in care or therapeutic technique, but more to give courage to others in attempting to relieve similar extreme cases of hyperthyroidism.

Through the kindness of Dr. Lawrence Reynolds I was permitted to undertake the treatment of this case, after it had been referred to us from the medical department.

The patient, a young man twenty-seven years old, was admitted to the medical service on Sept. 12, 1919, complaining of extreme nervousness and restlessness, which seemed to be getting worse.

The family history was negative except for the fact that his mother evidently suffered from hyperthyroidism.

The past history is interesting because it elicits the fact that for several years he has been subject to attacks of fidgeting and twitching. Two years ago following an attack of pleurisy he had more or less of a nervous breakdown, the chief symptoms of which were fidgetings and insomnia, although he usually sleeps well. For the past three years nocturia has occurred about thrice each night. His best weight was 143 pounds seven years ago; on entrance to hospital it was 135.

The present illness has had rather a gradual onset, extending over the past year. Although always restless he has gradually become more so until now he is unable to keep his arms or head still, and his eyeballs twitch. Small matters began to worry him, and he noticed that he easily became exhausted. Five weeks ago he ceased work on the advice of his physician. During the past three weeks the nervousness has markedly increased, and his eyes occasionally became blurred. Two weeks ago he noticed an enlargement of his neck. No cardiac symptoms are evident. He now has enuresis.

The physical examination shows typical hyperthyroid symptoms such as enlargement of the gland, which is more marked on the right; a loud bruit, tachycardia, exophthalmos, lid lag, tremor of hands, sweating, etc. incidently his Wassermann is positive, and he has Hutchinsonian teeth.

On Sept. 29th his basal metabolism was found to be +65, and although receiving 5000 calories daily with complete rest in bed, he continually lost weight.

On Oct. 8th his metabolism was +95. Some doubt was expressed as to this really being a basal reading, due to his continual twitchings, so bromides were suggested but had no effect.

It was at this stage of the disease that the patient was referred to the *x*-ray department.

The pulse remained for the past few days at about 120, and the urine contained sugar.

The treatment was begun very cautiously, for with such a high metabolism, and the patient's nervous condition, his immediate reactions were somewhat problematical. Hence it was decided to give two or three small thymus doses first. These consisted of about 1 Hampson tint using a 9 in. gap with 5 mm. of aluminum as a filter.

Nothing remarkable happened after these trial doses, so after about ten days his metabolism was again done. It was +116, while the choreiform movements were increasing and his weight decreasing.

Under these rather extreme circumstances it was deemed best to use more intensive measures. So on Nov. 17th, 20th, and 24th, he had three doses to the thyroid over different areas, and on Dec. 1st one over the thymus. Each of these doses consisted of 3 Ha tints (¾ erythema) through 3 mm. Al. with a 9 in. gap.

After this series of treatments his pulse dropped from 132 to 92, but rose to 120 by Dec. 7th. Sugar was continually in the urine.

On Dec. 20th the metabolism was again done and found to be +79; he looked and felt much better. The pulse was 120, but the fundamental rate taken during sleep was only 100 to 110, whereas this was 120. The urine was sugar-free and he was gaining weight.

On Dec. 22nd, 27th and 30th he had a similar series to the thyroid, and during the following two weeks he showed steady improvement in weight, and the choreiform movements were practically gone.

The metabolism was now found to be +60.

On Jan. 13th, 16th and 21st the thyroid was again exposed. Following this his pulse remained low, his weight steadily increased, and the enuresis left him.

This time the metabolism was down to +49.

Although his metabolism was still much too high, still it was decided to allow things to remain as they were for a while, and see if a further drop would not occur without more treatment; for of course we know that the final effects of treatment not infrequently manifest themselves long after therapy has ceased. Hence after bringing down the metabolism 67 points, we thought it best to rest on our oars awhile, and watch the drift.

It might be interesting to report later on this case, after perhaps a year has elapsed, for undoubtedly thyroid cases should be followed over long periods of time really to establish the fact as to whether or not our cures are permanent.

REPORT OF FOUR CASES OF MALIGNANT DISEASE SUCCESSFULLY TREATED BY ROENTGEN THERAPY*

By A. F. TYLER, B.Sc., M.D.

OMAHA, NEB.

THE following case reports are of interest because of the extent of the disease and the technique employed in successfully treating them:

CASE 6626. Mrs. F. H., forty-four years old. Weight 90 pounds. Four years ago she noticed a lump in the right breast. In July, 1915, she consulted a doctor who found trouble in both breasts. Later, she visited the Mayo Clinic, where it was found she had cancer of the uterus, liver and both breasts. She was referred for roentgen therapy, coming December 13, 1915.

Technique.—105 K. V., 6 millimeters of aluminum and sole leather, 8 inch anode skin distance. A total of 1050 milliampere minutes divided into fourteen series.

Results.—She has had eighty-seven treatments, comprising fourteen series, covering the entire torso from the chin to the pubes, front, back and both sides. When she came she was bedfast and unable to eat or sleep because of the pain. Her pain disappeared, the uterine hemorrhage ceased, she gained weight, was able to sleep, and eat anything she liked. She has been doing her own housework for more than three years. Both breasts are soft and the liver is barely palpable, while the uterus is freely movable and normal size.

CASE 8445.—Mrs. A. F. S., forty-seven years, married. Up to three months previous to our examination, May, 1918, she had been well and her menstrual periods had been regular. At that time, she began to bleed profusely and constantly, which continued to the time of our observation. One month previous to our observation she was curetted and cauterized, as the whole pelvis was filled with a mass.

Diagnosis.—Massive carcinoma filling the pelvis.

Treatment.—105 K. V., 6 millimeters of aluminum and sole leather, 8 inch anode skin distance, 5 milliamperes, 15 minutes over each area, covering the abdomen from the navel to the pubes and corresponding area on the back. One such series in May, June, July, August, October and November. No treatment since.

Results.—She ceased flooding after the second series and has had no show since. Recent examination shows the uterus normal size and appearance and freely movable. No glands are palpable.

CASE 8990. Mr. D. C. C., fifty-six years, married, farmer. January 1, 1918, his throat began to get sore with difficulty in swallowing. In May a local physician sent him to Denver for diagnosis, when Dr. E. C. Hill examined a section and found it to be small round cell sarcoma. Later, Dr. Bevan recommended ligation of the carotid artery and radium therapy.

Examination.—July 19, 1918. Patient swallows liquids with difficulty, can only speak in a whisper. The entire pharynx is filled with a growth, smooth in character and apparently arising from the right tonsil. The right submaxillary and cervical glands are enlarged to the size of the patient's fist.

Treatment.—105 K. V., 6 millimeters of aluminum and sole leather, 8 inch anode skin distance, 200 milliampere minutes over each side of neck and down over the mediastinum. He had a second series of treatments one month later, using the same setting, giving 175 milliampere minutes. Two months later he had a third series with the same setting, using 150 milliampere minutes.

Results.—The third morning, after hav-

* Read at the Midwinter Meeting of the Middle Section of THE AMERICAN ROENTGEN RAY SOCIETY, Chicago, February 22, 1920.

ing had only two days' treatment, he walked into the office very happy because he had been able to eat a breakfast of griddle cakes, swallowing them without difficulty. A recent examination showed no evidence of the growth or of metastasis. He is in good health nineteen months after treatment.

CASE 10357. L. R. Age ten.

When eight years old he began to lose his sight. In December, 1918, he was examined by a competent ophthalmologist, who found a double optic atrophy and destruction of the sella turcica. Early in January, 1919, he was examined at the Mayo Clinic, where the above findings were confirmed, and in addition the roof of the pharynx was bulging and microscopical examination of adenoid tissue proved it to be fibro-sarcoma.

Roentgen examination at beginning of treatment.—Complete destruction of the sella turcica with the floor pushed down into the sphenoid space. Measurements, 25 x 25 mm.

Treatment.—105 K. V., 6 millimeters of aluminum and sole leather, 5 milliamperes of current, 8 inch anode skin distance, 15 minutes through each area, using three portals of entry over each temple and one between the eyes. He had one such series in February, one in March, one in April, one in May, June, July and September, 1919. He has had no treatment since.

Results.—When he first came he was barely able to distinguish light from darkness. Now he can read type 8 point size, the bulging has disappeared from the pharynx, and the sella turcica is filling in normally.

These cases are typical of some of the worst forms of inoperable malignancy, one showing carcinoma of both breasts and the uterus; one carcinoma of the uterus with fixation in the pelvis and involvement of the pelvic glands; the third, massive small round cell sarcoma of the tonsil with extensive involvement of the glands of the neck; the fourth, sarcoma of the middle fossa of the brain involving both optic nerves. The first patient has been well three years; the second nineteen months; the third, nineteen months; and the fourth, thirteen months. In none of them has there been any evidence of metastasis to date.

These cases emphasize the necessity of employing proper technique in roentgen therapy. I feel that we can learn a lesson from the radium therapeutists in giving massive doses of highly filtered rays. Every physician who has studied the question of technique in roentgen therapy of malignant growths has admired the results obtained by Pfahler of Philadelphia. A number of years ago I became an ardent admirer of him, and learned from him the technique which he was employing. At that time, I was failing in a percentage of cases in which I thought success ought to be obtained. I immediately went home and taking those same patients, applied the technique followed by Pfahler and succeeded in getting them entirely well. This practical demonstration of the value of the highly filtered rays accompanied by high voltage so impressed me that I have never deviated from it since that time in treating malignant new growths.

It is interesting to note the letters I have received from different men throughout the country; and with the exception of three, none of them are using real deep therapy technique as I understand it. Many men claim they get the same result by using a 7 inch spark gap and a 3 millimeter filter. My only answer to that kind of an argument is that experience has not proven this to be true in my case. I have been using as a routine all of the voltage which the Coolidge tube would carry, never using less than 95 kilo-volts, and when possible, going up closer to 115 than to 95. I have been using a parallel spark gap on my treatment transformer, and during the entire treatment keep the spark just spitting across 9¾ inches of air space. I am living in a rather dry climate, so I am getting more voltage with a 9¾ inch spark gap than one would get in a damp climate with the same spark gap, due to the fact that dry air has greater resistance to the passage of electricity than has moist air. Up to the present time I have been using a

treatment machine equipped with a rheostat control. When one is using a treatment machine equipped with an auto-transformer control, one can keep the voltage reading constantly at a certain point without using the parallel spark gap. Along with this high voltage I have been using 6 millimeters of aluminum and sole leather as filters. I have been using as a routine 5 milliamperes of current at an 8 inch anode skin distance. Measured by Hampson's radiometer—using this technique—it requires five minutes to give an erythema dose with the pastille resting on the skin underneath all of the filters. When I am treating malignant new growths I do not stop at the pastille erythema dose, but as a routine use three times the pastille dose, or 75 milliampere-minutes of current with the technique described above. In extensive diseases, where there is considerable vascularity and the condition points toward the fact that we should get as quick an action as possible, I even give as high as 225 milliampere-minutes, or 9 times the pastille dose over the same area. Of course I do not advise this extreme dosage without caution because this produces a burn. The reaction from it is tremendous, but when the growth is located in the soft tissues near the surface so that ulceration will do no harm, I employ it. I also employ this maximum dosage in the treatment of sarcoma. The burn produced by this treatment heals very quickly and looks and acts like the burn produced by radium. Practically speaking, I think this technique and dosage has the same clinical effect as radium treatment. I have a statement from Hirsch of New York who is using only a 4 millimeter filter and a 9 inch parallel spark gap at sea level. He claims that by measuring the amount of rays passing through 4 millimeters of aluminum by means of a Christen meter, he finds there is little advantage gained by the additional 2 millimeters of aluminum. Arthur F. Holding did considerable experimental work during the years 1912-17, relative to the value of different thicknesses of filters, using the photographic effect of the ray upon sensitive plates. His report shows little difference in the photographic effects of the ray when passed through 4 millimeters of aluminum and when passed through 6 millimeters of aluminum. Even though this test on the photographic plate shows little difference when 4 or 6 millimeters of aluminum filter is used in my hands, as well as in the hands of Pfahler, Boggs and Ballard, the clinical effect on the patient is considerably different. There is more caustic action on the skin with the same dosage using 4 millimeters filter than when using 5 millimeters filter. The growth does not seem to melt down as fast under the thinner filter as under the thicker filter and high voltage. The skin recovers more quickly when the heavy filter and high voltage are used than when the thin filter is used. Of course the better effects may be due to the high voltage rather than to the amount of filter. I am convinced that both elements, together with the massive dosage, are responsible for my results.

In conclusion, it would seem that a standard technique could be adopted for deep therapy. The author favors 105-115 K. V., together with 6 millimeters of aluminum and sole leather filter working at an 8 inch anode skin distance. This technique combined with massive dosage in experienced hands will result in the maximum good from deep *x*-ray therapy in malignant growths.

PATHOLOGICAL FINDINGS IN ONE THOUSAND ROENTGEN RAY EXAMINATIONS OF THE DIGESTIVE TRACT*

By W. WARNER WATKINS, M.D.

Pathological Laboratory

PHOENIX, ARIZ.

"THE study of living pathology," says Deaver,[1] "is the important contribution of modern surgery to the medical sciences." This can be said just as truly of roentgenology. Leonard[2] in his memorable "Report on Radiography of the Stomach and Intestines" thus expressed it: "The *living* anatomy, physiology and pathology (of the digestive tract) has yet to be written, and this can only be done as the results are determined by the study of the living patient by the roentgen method."

The advantages of studying living pathology by the roentgen method, over the exploratory operation advocated by Roberts,[3] will appeal at least to the patient. In his article, speaking of the limitations of the roentgen examination, Roberts says: "A negative roentgen ray diagnosis of a gastrointestinal lesion should never be regarded as final in the exclusion of gastrointestinal disease." No roentgenologist would ever so regard it; only the too credulous internist or surgeon takes this view, just as he frequently, and very erroneously, regards a negative Wassermann as excluding syphilis. Not only will the roentgenologist not regard his own negative findings as conclusive, but he will not regard the negative exploration of the abdomen by a surgeon as final, unless the hollow viscera are all opened and inspected and the solid viscera all removed and examined by a tissue pathologist. We ask only two things: first, that our work be regarded not as an "*x*-ray diagnosis," but as a consultation roentgen examination in which we desire a full knowledge of the clinical history and symptoms of the patient, to be correlated with our own observations; second, that our *positive* findings be given the consideration which they deserve, as opinions of consultation specialists; if these opinions are supported by the positive demonstration of pathology, so much the better; if they are only opinions, let them carry the weight to which they are entitled in the mind of the clinician by reason of the "pathologic knowledge, experience and scientific honesty" desired by Roberts in *x*-ray interpretation.

This report of one thousand *x*-ray examinations has a threefold object: To tabulate the findings in patients coming to the general practitioner with chronic symptoms referred to the digestive tract; to illustrate the importance of thorough gastrointestinal *x*-ray examinations, no matter how definite the symptoms may appear; to demonstrate the frequency of certain lesions and of combined lesions of the digestive tract.

These one thousand patients were examined between May, 1916, and November, 1919, and were referred by thirty-five physicians and surgeons. They all came with definite symptoms in the digestive tract or with evidence that gastrointestinal diseases were present. Four hundred came without a history or any information as to the character of the symptoms; 270 with symptoms pointing to stomach or duodenal lesions; 155 with symptoms suggesting gall-bladder disease; 140 with symptoms suggesting appendix disease; and 35 with symptoms suggesting lesions of the colon.

The lesions found in the 400 patients with indefinite symptoms are shown in Table I. The findings were negative in 92 patients; uncomplicated appendix disease was found in 90; duodenal ulcer in 28; stomach ulcer in 18; peritoneal adhesions in 38; chronic gall-bladder disease in 27; tuberculous colitis in 18; diverticuli of the colon in five; cancer of stomach in five; cancer of colon in five,

* Read at the Winter Meeting of the Pacific Coast Roentgen Ray Society, San Francisco, Cal., December 5-6, 1919.

with isolated cases of several other conditions. There were 53 cases in this group showing multiple lesions.

The lesions found in the 270 patients coming with symptoms of stomach or duodenal disease are shown in Table II. Uncomplicated gastric or duodenal lesions were found in 137, multiple lesions in 21, with negative findings in 57.

The lesions found in the 155 patients with symptoms of gall-bladder disease are shown in Table III. In 89 of these a diagnosis of gall-bladder disease, with or without complications, was made; lesions outside the gall-bladder were found in 27, and the examinations were negative in 44.

The lesions found in the 140 patients coming with symptoms pointing to appendix disease are shown in Table IV. In only 26 of these were the findings negative, pathological conditions in the appendix region being found in 97.

The lesions shown in the 35 patients with symptoms limited to the colon, are shown in Table V.

In Table VI, the pathological conditions found in the entire series are listed in the order of their frequency, and some of these results will bear discussion.

Negative results in the *x*-ray examinations of 240 out of 1000 patients with definite symptoms in the digestive tract are not surprising. They are due to one of three reasons: (a) failure on the part of the clinician to have a complete examination; (b) reflex symptoms in the digestive tract caused by lesions elsewhere; (c) failure to demonstrate the lesions present. The first of these causes is the most important one in this series, but lack of space prevents a discussion of this fault on the part of the clinician.

Chronic Appendicitis: The most interesting observation in this series is the frequency of chronic appendix disease. The literature of the past ten years on chronic appendicitis is strikingly similar to that of twenty-five or thirty years ago on acute appendicitis, in the wide variety of opinions both as to the existence of such a condition, and as to the proper treatment for it when its reality is admitted. The *Journal of the American Medical Association* in 1907 [5] reviewed an article by Klemm of the previous year and said, among other things: "The fact that there are chronic cases in which there are no definite attacks and but few symptoms referable to the appendix has been recognized for some years. * * * There is little doubt that cases of this sort are frequently overlooked and diagnosed as intestinal indigestion or dyspepsia." Since that time numerous articles have appeared with the utmost variance in opinion. The absolute negative view is represented by Cabot [6] who tabulates 15,000 cases of chronic dyspepsia, 12,600 of them caused by non-gastric conditions, among which chronic appendicitis is not included, even as a possible cause. Bevan,[7] Connell,[8] Williams and Slater,[9] and Roberts [3] take the stand that chronic appendicitis is greatly over-estimated and should not be taken seriously unless there is a definite history of an acute attack. If these writers are weak in their pathology, they have, at least, excellent legal backing, since the Circuit Court of Appeals of Maryland [10] has handed down a decision to the effect that chronic appendicitis is not a disease; that acute appendicitis is an emergency demanding treatment, but chronic appendicitis is only a misfortune which may or may not call for medical attention. The opposite extreme, that pathological changes in the appendix, whether obliteration, fibrosis, adhesions, or inflammation, are emergencies demanding surgery, is upheld by Sonnenburg,[11] Richelot,[12] Schwartz,[13] Bastedo,[14] Bassler,[15] Pfeiffer,[16] Aaron,[17] Jacobson,[18] Bristow,[19] and Vivian.[20] What may be termed the conservative view and the one, therefore, most likely to be correct, is taken by Deaver,[1] C. H. Mayo,[21] Murphy,[22] Horsley,[23] Brewer,[24] Moynihan,[25] Graham, Stanton, Lichty [26] and Cheney.[29] These latter writers recognize chronic appendicitis as a cause of gastrointestinal symptoms, and have varying explanations for the observation that appendectomy frequently fails to relieve

the symptoms complained of by the patient.

The argument of Williams and Slater [9] that, because a diseased appendix is frequently found incidental to other operations, it is, therefore, an innocent condition, is no more justifiable than would be the similar claim that gall-stones should be disregarded because they frequently exist without symptoms. The fact that a patient may carry a pathological condition indefinitely without distress is no proof of its innocence as a potential or actual danger. The contest about chronic appendicitis, as with other lesions, centers on the border-line cases where the internist and surgeon differ as to treatment, and endeavor to make the roentgenologist assume the responsibility of the decision. Where we have been foolish enough to do this, we have come into well-deserved disrepute. This decision is not our function. We should demonstrate the pathology, if we can; if we cannot demonstrate it, we may give an opinion as to the conditions present, without ocular proof on the radiograph. But to say whether the appendix should be removed and whether the patient is to look for relief afterwards, is not within our province; this is a matter of the skill and thoroughness of the surgery plus the wisdom and persistency of subsequent medical treatment. Stanton,[27] in his critical paper on Postoperative End Results in Chronic Appendicitis, says that unless it is perfectly evident that the appendix is the sole offender, the gall-bladder, stomach and right kidney should be explored. Frequently a direct operative procedure can be substituted for this exploration by the *x*-ray demonstration of other lesions complicating appendix disease. Leede [30] calls attention to the observation that many symptoms considered to be due to chronic appendicitis are caused by associated colitis, typhlitis, or movable cecum. Wilms [31] has called attention to the importance of a long and movable cecum. Brown [32] believes that the misinterpretation of conditions around the cecum and the lack of cooperation between the surgeon and physician in these chronic cases, explains many operative failures. Pfeiffer [16] thinks the failure of many operations to relieve pain is due to inattention to the meso-appendix. Horsley [23] says: "Operations for chronic appendicitis, while practically free from mortality, do not always relieve morbidity. The essential cause of unrelieved pain is the fact that the condition which produced the pain was not relieved. Either the diagnosis was not accurate, and such diseases as stone in the kidney, spinal arthritis, ulcer of the duodenum or stomach, Lane kink, were not excluded, or else the local conditions about the appendix were not correctly interpreted."

The statements of Bevan, Roberts, Connell and others, that a chronic appendicitis, without history of an acute attack, should not be taken seriously, is not in harmony even with the pathology of the acute condition. When an acute gangrenous appendicitis can occur without pain, why cannot, much more frequently, lesser degrees of appendix infection occur without pain? Moschcowitz,[33] Pfeiffer, McCarty,[34] and other pathologists have shown that a mucosal appendicitis has no occasion to be painful, since the sensory nerves of the appendix are in the meso-appendix. Jacobson [18] thinks an acute appendicitis is simply the violent sequel of a chronic and usually painless process which develops the proper local conditions for an acute inflammation. This view is interesting, since this series includes several cases showing chronic appendicitis on *x*-ray examination who were operated for acute appendicitis weeks or months later. We believe with Goltman [35] that the term "symptomless appendicitis" is incorrect, because no pathology is without symptoms; but we do firmly believe that an acute appendicitis may be painless and that chronic appendicitis usually is painless.

We should like to review the excellent work done by roentgenologists on chronic appendicitis, for their observations have crystallized the differences in opinion mentioned, and it will be their continued work which eventually will clarify the situation and establish the correct pathological under-

standing of chronic appendicitis. Because of lack of space, we can only say that the work reported here is in accord with the viewpoint of roentgenologists in general.

In a gastrointestinal examination, the roentgenologist may find demonstrable pathology in the appendix, either as the only abnormality, or in association with other lesions. This pathology may be visualized in an appendix which is retrocecal and tender, kinked, constricted, irregularly filled, adherent to adjacent structures, containing concretions, or atonic and unable to empty. He may infer appendix disease from other pathology found in the ileocecal region, such as adhesions, Lane kink, obstruction at the valve, cecal stasis, etc. He can utilize the inflation test described by Bastedo with a colon enema, the pinching test described by Bassler, or observe the pylorospasm reflex mentioned by Aaron. He is then entitled to report that there is a pathological appendix which, in his opinion, is capable of producing local or reflex symptoms or both.

After appendix disease has been established, the clinician or surgeon still has several things to decide: (a) whether the diseased appendix is actually the cause of the symptoms complained of by the patient; (b) if so, whether there are associated causes outside of the gastrointestinal tract; (c) if other gastrointestinal lesions are shown by *x*-ray, what relation they bear to the symptoms, and whether they are surgically remediable along with the appendix; (d) to what extent conditions like atony of the colon, constipation, ptosis of the cecum, neuroses of the stomach, some of which will have been demonstrated by the *x*-ray examination, will be corrected by the proposed surgery and subsequent medical treatment; (e) whether the patient will be amenable to postoperative medical treatment.

Our observations that chronic appendicitis produces chiefly reflex symptoms, no leucocytosis, but gives characteristic roentgenological findings, confirms the previously reported conclusions of Cheney [20] and Vivian [20] that the condition may be chronic from the start, and an acute onset of any sort is not essential to a diagnosis; that the patients either complain of stomach trouble or vague abdominal distress; that the radiographic examination is indispensable (Cheney).

In the series of one thousand patients, no fewer than 323 showed pathological appendices, this being the only demonstrable pathology in 212. There were 25 additional cases with ileocecal adhesions where the appendix was not shown; 29 cases of combined ulcer and appendicitis, and 46 cases of combined appendix and gall-bladder disease.

Chronic Cholecystitis: Next to appendicitis, chronic gall-bladder disease was the most common lesion found. We wish to state, without apology, that we follow the teaching, technic and conclusions of George[36] in gall-bladder work. His conclusions are: (1) The normal gall-bladder will not be shown on the radiograph; (2) a distinct and unmistakable gall-bladder shadow means a thickened wall or abnormally dense fluid; (3) such a shadow, with or without stones, means chronic cholecystitis; (4) chronic cholecystitis is a surgical condition. We do not, therefore, regard it as an error if we diagnose a chronic cholecystitis and fail to show stones which are afterwards found at operation. We have never had the experience of Roberts [3] in securing a shadow of a normal gall-bladder.

This series gave 183 patients with chronic gall-bladder disease, which was the sole pathology in 124 and was found in combination with other lesions in 59 cases.

Ulcer: Duodenal ulcer was found in 124 patients, being the only lesion in 91, and existing in combination with other lesions in 33. Stomach ulcer was demonstrated in 93 patients, alone in 62, and in combination with other lesions in 31.

We have learned to believe that the clinical symptoms are not sufficiently characteristic to permit an unqualified differentiation between stomach and duodenal ulcer, and usually warn the clinician not to place his ulcer too confidently, as it is likely to

be dislocated by the *x*-ray examination.

Adhesions involving the colon were found in 50 cases, 38 of these giving indefinite symptoms.

Cancer of the stomach was found in 36 patients.

Tuberculous Colitis was found in 24 patients, 18 of these giving indefinite symptoms. This finding was usually unexpected by the clinician, confirming Lawrason Brown's [37] statement that the symptoms depended on for diagnosis by the clinician are late developments in tuberculous colitis, and that it can be diagnosed by *x*-ray before it gives clinical symptoms.

Stomach Syphilis probably was not found as often as it occurred, being diagnosed only five times, two of these being congenital in infants. Two additional cases, diagnosed as cancer, proved to be syphilis.

Pyloric Stenosis was examined for seven times, being found twice and relieved by operation; three infants showed spasm without stenosis, and two proved to have congenital syphilis.

Diverticuli of the colon was diagnosed nine times, and duodenal diverticuli four times.

COMBINED LESIONS

The most interesting and instructive cases in this series were those showing combined lesions. This group, no doubt, would have been much larger had a complete examination been made in all cases, since many of the cases operated for a single lesion showed other lesions.

Ninety-five patients showed two distinct lesions and nine had triple lesions.

There were forty-six patients with combined gall-bladder and appendix disease; sixteen patients with duodenal ulcer and chronic appendicitis; thirteen patients with stomach ulcer and chronic appendicitis; eight patients with both stomach and duodenal ulcer; three cases of duodenal ulcer and gall-bladder disease; two cases of stomach ulcer and gall-bladder disease; one case each of appendicitis and ureteral stone; appendicitis and duodenal diverticulum; appendicitis and colon diverticuli; appendicitis and tuberculous colitis; appendicitis and spondylitis; duodenal ulcer and tuberculous colitis; duodenal ulcer and stomach cancer; gall-bladder disease and tuberculous colitis.

The triple lesions were as follows:

Six cases of gall-bladder and appendix disease with ulcer.

One case of gall-bladder disease with both stomach and duodenal ulcer.

One case of stomach and duodenal ulcer and chronic appendicitis.

One case of gall-bladder disease with stomach ulcer and tuberculous colon.

TABLE I

LESIONS FOUND IN PATIENTS WITH INDEFINITE SYMPTOMS.

Number Examined, 400

Negative	(23%)	92
Chronic Appendix Disease only	(22.5%)	90
Adhesions, (colonic)		38
Combined Gall-bladder and Appendix Disease		30
Duodenal Ulcer		28
Gall-bladder Disease		27
Stomach Ulcer		18
Tuberculous Colitis		18
Appendix Disease with Stomach or Duodenal Ulcer		15
Ileocecal Adhesions		14
Diverticuli of the Colon		5
Cancer of the Stomach		5
Cancer of the Colon		4
Stomach Syphilis		2
Appendix and Gall-bladder Disease with Stomach Ulcer		2
Incompetent Ileocecal Valve		1
Gall-bladder Disease with Ulcer		1
Chronic Appendix with Ureteral Stone		1
Chronic Appendicitis with Duodenal Diverticulum		1
Negative Gastrointestinal with Spondylitis		1
Cancer of Lungs and Liver		1
Negative Gastro-intestinal with Kidney Stone		1
Duodenal Ulcer, Gall-bladder Disease with valve obstruction		1
Negative Gastrointestinal with Adhesive Pericarditis		1
Duodenal Ulcer with Tuberculous Colon		1
Infantile Pylorospasm		1
Gall-bladder Disease with Tuberculous Colon		1

TABLE II

LESIONS FOUND IN PATIENTS COMING WITH DEFINITE SYMPTOMS OF STOMACH OR DUODENAL DISEASE

Number Examined, 270

Findings Negative	(21.5%)	57
Duodenal Ulcer		57
Stomach Ulcer		42
Cancer of Stomach		30
Chronic Appendicitis		26
Gall-bladder Disease		17
Stomach and Duodenal Ulcer		8
Appendix Disease and Ulcer		7
Pylorospasm		4
Stomach Syphilis		3
Gall-bladder Disease and Appendicitis		3
Duodenal Diverticuli		3
Tuberculosis of the Colon		2
Ulcer and Gall-bladder Disease		2
Ulcer, Gall-bladder and Appendix Disease		2
Appendicitis and Diverticuli		1
Ulcer and Tuberculous Colon		1
Cancer of Esophagus		1
Negative Gastrointestinal with Aneurism of Descending Aorta		1
Pyloric Stenosis		1
Diverticuli of Colon		1
Duodenal Ulcer and Stomach Cancer		1

TABLE III

LESIONS FOUND IN PATIENTS WITH SYMPTOMS OF GALL-BLADDER DISEASE.

Number Examined, 115

Negative Findings	(28%)	44
Gall-bladder Disease	(55%)	78
Gall-bladder Disease with Appendicitis		8
Chronic Appendicitis		7
Duodenal Ulcer		6
Ulcer with Appendicitis		3
Stomach Ulcer		2
Gall-bladder Disease with Ulcer		2
Stone in Liver		1
Diverticuli of Colon		1
Negative Gastrointestinal with Aneurism of Descending Aorta		1
Appendicitis plus Duodenal Diverticulum		1
Gall-bladder Disease, Appendix Disease with Ulcer		1

TABLE IV

LESIONS FOUND IN PATIENTS WITH SYMPTOMS OF APPENDIX DISEASE.

Number Examined, 140

Negative Findings	(18%)	26
Chronic Appendicitis		88
Ileocecal Adhesions		9
Appendix Disease plus Ulcer		4
Gall-bladder plus Appendix Disease		5
Gall-bladder Disease		2
Appendicitis with Tuberculous Colitis		2
Tuberculous Colitis		2
Stomach Ulcer, Gall-bladder Disease with Tuberculous Colitis		1
Chronic Appendix with Spondylitis		1

TABLE V

LESIONS FOUND IN PATIENTS WITH SYMPTOMS OF COLON DISEASE.

Number Examined, 35

Negative Findings	12
Colonic Adhesions	12
Incompetent Valve	4
Ileocecal Adhesions	2
Diverticuli of Colon	1
Chronic Appendix	1
Colitis	1
Enlarged Spleen	1
Appendix and Gall Bladder Disease	1

TABLE VI

LESIONS SHOWN BY *x*-RAY IN ONE THOUSAND PATIENTS WITH GASTROINTESTINAL SYMPTOMS

Negative Findings

Absolutely Negative	231
Negative, with Enlarged Spleen	1
Negative, with Aneurism	2
Negative with Cancer of Esophagus	1
Negative, with Spondylitis	1
Negative, with Kidney Stone	1
Negative with Adhesive Pericarditis	1
Negative, with Cancer of Lungs	2
Total Patients with Negative Findings for Gastrointestinal Pathology, (24%)	240

Appendix Pathology

Chronic Appendicitis alone	212
Ileocecal Adhesions	25

TABLE VI *(continued)*

Appendicitis with Gall-bladder Disease	46
Appendicitis plus Ulcer	29
Appendicitis, Gall-bladder Disease and Ulcer	6
Appendicitis and Ureteral Stone	1
Appendicitis and Duodenal Diverticulum	1
Appendicitis and Colon Diverticuli	1
Appendicitis and Tuberculosis of Colon	1
Appendicitis and Spondylitis	1
Total Patients showing Appendix pathology (32.3%)	323

Gall-Bladder Disease

Chronic Cholecystitis (31 cases showed gall stones)	124
Gall-bladder and Appendix Disease	46
Gall-bladder Disease and Ulcer	5
Gall-bladder Disease, Ulcer and Appendicitis	6
Gall-bladder Disease and Tuberculous Colon	1
Gall-bladder Disease, Ulcer and Tuberculous Colon	1
Total Patients Showing Gall-bladder Disease, (18.3%)	183

Duodenal Ulcer

Duodenal Ulcer alone	91
Duodenal Ulcer and Appendicitis	16
Duodenal and Stomach Ulcer	8
Duodenal Ulcer and Gall-bladder Disease	3
Duodenal Ulcer, Gall-bladder and Appendix Disease	3
Duodenal and Stomach Ulcer and Gall-bladder Disease	1
Duodenal Ulcer and Cancer of Stomach	1
Duodenal Ulcer and Tuberculosis Cerum	1
Total Patients showing Duodenal Ulcer, (12.4%)	124

Stomach Ulcer

Stomach Ulcer alone	62
Stomach Ulcer and Appendicitis	13
Stomach and Duodenal Ulcer	8

TABLE VI *(continued)*

Stomach Ulcer, Gall-bladder and Appendix Disease	3
Stomach Ulcer and Gall-bladder Disease	2
Stomach Ulcer and Adhesions	2
Stomach and Duodenal Ulcer with Gall-bladder Disease	1
Stomach Ulcer and Tuberculous Colon	1
Stomach Ulcer, Gall-bladder Disease and Tuberculosis of Colon	1
Total Cases with Stomach Ulcer (9.3%)	93
Colon Adhesions	50
Cancer of the Stomach	35
Do. with Duodenal Ulcer	1
Total	36
Tuberculous Colitis	20
With Ulcer and Gall-bladder Disease	1
With Gall-bladder Disease	1
With Ulcer	2
Total	24
Diverticuli of Colon	9
Syphilis of the Stomach	5
Cancer of the Colon	5
Duodenal Diverticuli	4
Valve Incompetency	5
Pyloris Stenosis in Infants	2
Pylorospasm without Stenosis	3
Stone in the Liver	1

Through the courtesy of Drs. Willard Smith, W. O. Sweek, E. Payne Palmer and Geo. E. Goodrich, the operative findings on 146 patients of the reported series have been secured, and are given in Table VII, in parallel columns with the *x*-ray findings. For the sake of convenience those cases in which there was disagreement in the *x*-ray and operative findings are given first (Nos. 1-35):

TABLE VII

X-RAY AND OPERATIVE FINDINGS IN 146 CASES SHOWN IN PARALLEL COLUMNS.

CASE	*Serial X-ray*	*X-ray findings*	*Operative findings.*
1.	3810	Ileocecal and colon adhesions; gall-bladder not examined.	Ascending colon densely bound by adhesions; gall-stones.
2.	6301	Duodenal ulcer; appendix not examined.	Old duodenal ulcer; chronic appendicitis.
3.	4047	Duodenum adherent to gall-bladder; appendix not examined.	Adherent gall-bladder; chronic adherent appendicitis.
4.	8481	Stomach only examined. Negative.	Tuberculous enteritis and appendix.
5.	4100	Stomach and colon negative. Gall-bladder not examined.	Chronic gall-bladder and appendix disease.
6.	8042	Stomach only examined. Negative.	Chronic appendicitis.
7.	4494	Stomach only examined. Negative.	Chronic appendicitis and salpingitis.
8.	3171	Stomach only examined. Negative.	Tuberculous peritonitis.
9.	4618	Chronic appendix; cecum only examined.	Duodenal diverticulum. Chronic appendix.
10.	9304	Stomach only examined. Negative.	Perforated appendix.
11.	6346	Stomach and gall-bladder negative. Cecum not examined.	Acute appendicitis some months later.
12.	6020	Stomach only examined. Negative.	Acute appendicitis later.
13.	8470	Negative.	Adherent subacute appendicitis.
14.	6074	Negative.	Acute appendicitis later.
15.	4543	Negative.	Acute appendicitis later.
16.	3812	Chronic appendicitis. Chronic gall-bladder disease.	Acute, gangrenous appendix several weeks later; gall-bladder not examined at operation.
17.	2987	Pyloric ulcer; chronic appendicitis.	Chronic appendicitis; no ulcer by palpation.
18.	6705	Duodenal ulcer; ptosis of cecum.	Chronic appendicitis; ulcer not felt by palpation.
19.	4196	Duodenal ulcer.	Chronic appendicitis; ulcer not felt.
20.	8809	Duodenal ulcer; chronic appendicitis.	Chronic appendicitis; no ulcer felt.
21.	8660	Pyloric ulcer.	Subacute appendicitis; no ulcer felt.
22.	7099	Pyloric ulcer.	Acute appendix on chronic base; no ulcer felt.
23.	6082	Enlarged and thickened gall-bladder; pyloric ulcer; chronic appendicitis.	Very large gall-bladder with 586 small stones and one large stone in common duct; no ulcer felt; chronic pancreatitis. Appendix not examined.
24.	5109	Early cancer of stomach.	Disappeared under antiluetic treatment.
25.	7308	Possibly malignant colon.	No malignancy; adhesions at splenic flexure.
26.	9008	Probable cancer at splenic flexure.	Annular constriction at splenic flexure,—not malignant.

TABLE VII *(continued)*

CASE	*Serial X-ray*	*X-ray findings*	*Operative findings.*
27.	9578	Duodenal ulcer.	Carcinoma of pancreas, involving gall-bladder and duodenum.
28.	10112	Adhesions 2nd portion of duodenum. Gall-bladder disease (?)	Pyelitis and kidney abscess; adhesions to retroperitoneal duodenum; chronic appendicitis.
29.	3010	Neoplasm of stomach.	Nothing abnormal found in stomach.
30.	7531	Diverticuli of colon.	Pelvic adhesions; no diverticuli.
31.	9916	Diverticuli of colon.	Mesenteric adhesions; no diverticuli.
32.	4976	Normal stomach; chronic appendicitis.	Gastric ulcer; chronic appendicitis.
33.	8348	Cancer of pylorus.	Cholecystitis with stones and adhesions to pylorus.
34.	4110	Chronic gall-bladder disease.	Chronic appendix disease.
35.	3102	Gall-bladder disease with one stone.	No stone found; thickened gall-bladder.
36.	3839	Obstruction at splenic flexure.	Obstruction at flexure due to floating left kidney.
37.	6027	Chronic appendicitis.	Chronic appendicitis.
38.	7193	Chronic appendicitis with concretions.	Chronic appendicitis; two large concretions.
39.	5911	Retrocecal appendix with concretions.	Retrocecal tuberculous appendix.
40.	4345	Chronic gall-bladder disease.	Cholecystitis; many small stones.
41.	5282	Pathological gall-bladder.	Thickened gall-bladder with stones; cancer of liver.
42.	5484	Chronic gall-bladder with stones.	Cholecystitis with stones.
43.	8232	Surgical gall-bladder.	Gall-bladder and cystic duct filled with small stones.
44.	9293	Chronic appendicitis.	Chronic appendicitis.
45.	8309	Cancer of stomach and colon.	Confirmed.
46.	8241	Obstruction at valve.	Chronic appendicitis with Jackson veil.
47.	8493	Chronic appendicitis; duodenal ulcer.	Chronic appendicitis and veil; old duodenal ulcer.
48.	8818	Chronic appendicitis.	Appendix buried in adhesions.
49.	9977	Tuberculous colon.	Tuberculous colitis, appendicitis and peritonitis.
50.	6909	Tender cecum and appendix, probably tuberculous.	Appendicitis,—not tuberculous.
51.	6471	Chronic appendicitis, with concretion and adhesion.	Confirmed by operation.
52.	6265	Tender, adherent appendix perforation shadow.	Subacute appendicitis; perforation pocket.
53.	4790	Negative.	Confirmed by autopsy after accidental death.

TABLE VII *(continued)*

CASE	*Serial X-ray*	*X-ray findings*	*Operative findings.*
54.	4584	Ileo-cecal adhesions and Jackson veil.	Confirmed; bowel obstruction 4 days later.
55.	4391	Chronic appendicitis and colitis.	Acute appendicitis on chronic base.
56.	4312	Appendix normal.	Confirmed by operation for pelvic pathology.
57.	4295	Chronic appendicitis.	Confirmed by operation.
58.	3370	Chronic appendicitis.	Acute appendicitis on chronic base, several weeks later.
59.	3241	Small pathologic appendix.	Chronic appendicitis with acute area.
60.	9311	Chronic appendicitis with concretion.	Confirmed by operation.
61.	5710	Chronic appendicitis with ileo-cecal adhesions.	Confirmed by operation.
62.	6520	Chronic appendicitis.	Confirmed by operation.
63.	4436	Retrocecal adherent appendix.	Confirmed by operation.
64.	4445	Surgical appendix, adherent in pelvis.	Confirmed by operation.
65.	4261	Adherent, chronic appendix.	Acute appendicitis on chronic base.
66.	3740	Adhesions of colon.	Confirmed by operation.
67.	3483	Adhesions of colon.	Confirmed by operation.
68.	3788	Negative gall-bladder.	Confirmed by exploration.
69.	3790	Adherent, chronic appendix.	Acute appendicitis on chronic base.
70.	2747	Pathologic appendix, kinked and adherent.	Subacute appendicitis.
71.	3069	Negative cecum and appendix.	Confirmed by pelvic operation.
72.	3425	Pathological gall-bladder, probably with stones.	Dense adhesions about old gall-bladder drainage operation.
73.	9143	Pathology in cecal region probably from old appendix disease.	Chronic appendicitis; tuberculosis of tubes and ovaries.
74.	8195	Typhlitis and colitis.	Chronic appendicitis; adhesions.
75.	6535	Cecum adherent in pelvis. Duodenal ulcer (?)	Acute appendicitis, later; stomach not examined.
76.	5365	Jackson veil; chronic appendicitis.	Adhesions; chronic appendicitis.
77.	5018	Pathologic appendix; gall-bladder disease (?)	Chronic appendicitis.
78.	4101	Adhesions cecal region and along transverse colon.	Adhesions of omentum and colon to old operation scar.
79.	3979	Chronic appendicitis.	Chronic appendicitis.
80.	3820	Chronic appendicitis.	Chronic appendicitis.
81.	3464	Chronic appendicitis with concretions.	Chronic appendicitis.
92.	7621	Gastric ulcer; obstruction.	Gastric ulcer.
83.	5848	Pathologic appendix.	Chronic appendicitis.
84.		Ulcer of duodenum.	Duodenal ulcer; cancer of liver.

TABLE VII *(continued)*

CASE	*Serial X-ray*	*X-ray findings*	*Operative findings.*
85.	4816	Negative.	No organic lesions; ptosis.
86.	4599	Chronic gall-bladder and appendix disease.	Chronic appendicitis; gall-bladder not inspected.
87.	3332	Undetermined pathology in upper right, involving pylorus, duodenum and colon.	Pyloric ulcer with stenosis and extensive adhesions.
88.	3141	Negative except stasis.	No organic lesions.
89.	3073	Chronic gall-bladder disease.	Chronic cholecystitis.
90.	1036	Obstruction, hernia or intestinal fistula.	Hernia with obstruction by twisting of sigmoid.
91.	2231	Ileocecal and colon adhesions.	Adhesions with partial obstruction.
92.	10010	Pyloric ulcer.	Pyloric ulcer; chronic gall-bladder disease; pancreatitis; chronic appendicitis.
93.	9745	Pyloric ulcer.	Pyloric ulcer.
94.	9278	Pyloric ulcer.	Pyloric ulcer.
95.	8860	Advanced cancer of stomach. Metastasis in lung.	Confirmed by operation and death from lung involvement.
96.	8004	Duodenal ulcer.	Duodenal ulcer.
97.	7978	Stomach ulcer.	Large ulcer lesser curvature.
98.	9826	Chronic appendicitis.	Chronic appendicitis.
99.	9717	Chronic appendix and gall-bladder disease.	Chronic appendicitis and cholecystitis with adhesions.
100.	9714	Chronic appendicitis.	Chronic appendicitis.
101.	8695	Pathologic gall-bladder.	Chronic gall-bladder and appendix disease.
102.	8356	Ileo-cecal adhesions.	Cecum adherent in pelvis.
103.	8240	Gall-stones.	Chronic gall-bladder disease with stones.
104.	8092	Pyloric ulcer.	Chronic pyloric ulcer with stenosis.
105.	8034	Chronic appendicitis.	Subacute appendicitis.
106.	6984	Early cancer of stomach.	Large pyloric ulcer with obstruction. No pathological examination.
107.	6818	Chronic appendicitis.	Chronic appendicitis.
108.	6770	Pyloric ulcer.	Ulcer of stomach.
109.	5266	Chronic retrocecal appendix.	Chronic appendicitis; retrocecal.
110.	4556	Stomach ulcer.	Pyloric ulcer; adhesions to myoma of uterus.
111.	4085	Cancer of stomach.	Advanced cancer posterior wall of stomach.
112.	3805	Advanced cancer of stomach.	Advanced stomach cancer.
113.	3423	Tuberculous appendix.	Chronic appendicitis; tuberculous.

TABLE VII *(continued)*

CASE	*Serial X-ray*	*X-ray findings*	*Operative findings.*
114.	2939	Gall-stones; pyloric ulcer; chronic appendicitis.	Gall-stones; pyloric adhesions. Appendix not removed.
115.	2284	Degenerating ulcer or early cancer.	Cancer of pylorus; resected.
116.	1974	Duodenal diverticulum.	Fistulous tract between duodenum and gall-bladder, with one stone in gall-bladder.
117.	1803	Gall-bladder disease.	Chronic cholecystitis.
118.	9059	Gall-stones and adhesions. Cecum not examined.	Gall-stones and chronic appendicitis.
119.	10052	Chronic appendicitis.	Chronic appendicitis.
120.	10027	Pyloric ulcer; Lane kink.	Right oblique hernia and appendicitis. Stomach not examined.
121.	9028	Chronic appendicitis.	Chronic appendicitis.
122.	9000	Obstruction at valve.	Chronic appendicitis with adhesions.
123.	9074	Appendix involvement.	Adhesions of cecum to right tube; both tubes attached to abdominal wall by previous operator.
124.	9601	Chronic appendicitis.	Chronic appendicitis.
125.	8141	Chronic appendicitis.	Chronic appendicitis.
126.	3470	Tuberculosis of cecum and ascending colon.	Tuberculous destruction of cecum and part of ascending colon.
127.	3353	Chronic appendix disease with extensive adhesions.	Extensive adhesions requiring ileo-sigmoid-ostomy.
128.	4171	Chronic appendicitis.	Appendicitis with subphrenic abcess.
129.	3947	Gall-stones.	Gall-stones.
130.	3373	Cecum adherent in pelvis.	Chronic appendicitis with adhesions.
131.	3305	Gall-bladder and appendix disease.	Chronic cholecystitis and appendicitis.
132.	10301	Gall-bladder disease with small stone in common duct.	Chronic cholecystitis with medium size stone in common duct.
133.	1141	Pyloric ulcer.	Pyloric ulcer.
134.	9076	Large saddle ulcer or cancer of pylorus.	Carcinoma of stomach, resected.
135.	10191	Negative.	Pancreatitis with adhesions about common duct.
136.	5044	Cancer of sigmoid.	Annular cancer of sigmoid.
137.	4912	Retrocecal appendix.	Confirmed by operation.
138.	4663	Colon adhesions.	Confirmed by operation.
139.	1959	Chronic gall-bladder and appendix disease.	Confirmed by operation.
140.	3214	Chronic appendicitis; no ulcer.	Confirmed by operation.
141.	2940	Cancer of pylorus.	Confirmed.

TABLE VII *(continued)*

CASE	*Serial X-ray*	*X-ray findings*	*Operative findings.*
142.	4726	Chronic gall-bladder disease.	
143.	4268	Chronic appendicitis and gall-bladder disease.	Confirmed by operation.
144	3238	Chronic gall-bladder disease; pyloric ulcer; ileo-cecal adhesions.	Confirmed by operation. Cholecystitis with stones.
145.	3285	Chronic gall-bladder disease; probably stones.	Chronic cholecystitis; no stones.
146.	3956	Chronic appendicitis adherent in pelvis.	Chronic appendicitis, adherent to right ovary.

It will be noticed that in 35 cases there was more or less disagreement between the *x*-ray and the operative findings, while in 111 of the 146 patients, the *x*-ray examinations correctly foretold the operative findings.

Of the 35 cases in which there was disagreement in the findings, the first 10 patients were only partially examined, the lesions being found, at operation, in organs not examined by the roentgen ray. The next 6 patients gave negative examinations for appendix disease, but were operated for acute appendicitis at later periods; these were either cases of chronic appendix disease with acute terminations, or the occurrence of acute appendicitis in them was merely coincidence. The next 7 cases gave *x*-ray evidences of ulcer, but at operation none was found by palpation; rather than enter, at this time, into the argument over the reliability of excluding ulcer by palpation, we shall class these cases as errors of the roentgenologist. The remaining 12 cases were clearly errors of the roentgenologist in his conclusions.

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A CASE OF DIAPHRAGMATIC HERNIA WITHOUT SEVERE SYMPTOMS DISCOVERED ON ROUTINE X-RAY EXAMINATION OF CHEST

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THE great majority of the cases of diaphragmatic hernia have heretofore been reported by surgeons, who have found the condition in emergency operations, or by others who have found the condition at autopsy, Seibert,[5] who has made a thorough review of the literature, found that Leichtenstein had reported 250 cases, only 5 of which had been diagnosed before death. Diagnosis from the physical findings alone is difficult. The history of trauma followed by gastrointestinal symptons is only suggestive and certainly not specific, and only can a positive diagnosis be made from roentgenological findings.

Now that fluoroscopic and roentgenographic examination of the gastrointestinal tract is becoming more and more generally used we feel that diaphragmatic hernia will be more often diagnosed and cease to be a mere surgical curiosity.

Usually diaphragmatic hernia follows severe trauma, either severe blows, contusions, stab wounds, or even prolonged labor. The symptoms—pain, vomiting, signs of obstruction, etc., very soon follow the injury. Rarely, as in this case where there is no real obstruction, may the symptons be slight. All that this patient complained of was belching gas, bilious attacks, sour stomach and constipation.

There is no reason to believe that the diaphragm should not be the seat of hernia as well as other parts of the abdominal wall. Violence being the direct cause, any anatomical variation in the diaphragm may favor its establishment there.

Here the "paradoxic respiratory phenomena," the upward movement of the left diaphragm as the right moves down on deep inspiration, as described by Carman and Miller,[2] was doubtful. The fundus of the stomach was fixed within the thorax, its wall permanently held in a distended condition.

CASE NO. 1011. Mr. F. S. came to the Sanatorium complaining of a tickling cough, loss of weight and strength, indigestion, and constipation. No history of severe illness. The appetite of the patient is good; he is a moderate eater; eats meats, sweets and vegetables once a day. Teeth are in fair condition. He has suffered very much in the past with indigestion, nausea and vomiting; has pain in the stomach due to distention and is relieved by belching. Bowels are irregular and somewhat constipated.

When the patient was about thirteen years of age he was struck in the abdomen. He was unconscious for about fifteen minutes but had no other immediate after effects. About this time he began to have headaches which were migrainous in type. For the last twenty-five years these headaches and constipation have been persistent. The latter has been relieved by olive oil and hot water. Once every four or five days for the last twenty years he has had a heavy feeling in the stomach which comes on in the afternoon, gradually increases, and is aggravated by food. A physic relieves this condition. At times he vomits greenish, slimy water which also relieves him.

There is no shortness of breath or palpitation.

He has not been well since 1912, when sugar was found in his urine. Under proper diet this soon cleared up. Several exami-

nations here failed to reveal any sugar.

The physical examination, except for slight ptosis of the right kidney, tenderness on deep pressure over the appendix, and chest findings, was negative. There was broncho-vesicular breathing above the right clavicle, with a few fine dry râles after coughing. At left base in front there was moderate impairment, absent vocal resonance, and feeble breath sounds. At the right back, a few fine dry râles could be detected after cough at apex. At the left back, there was moderate impairment; feeble breath sounds and absent vocal resonance were noted below the level of the eighth cervical vertebra to the base.

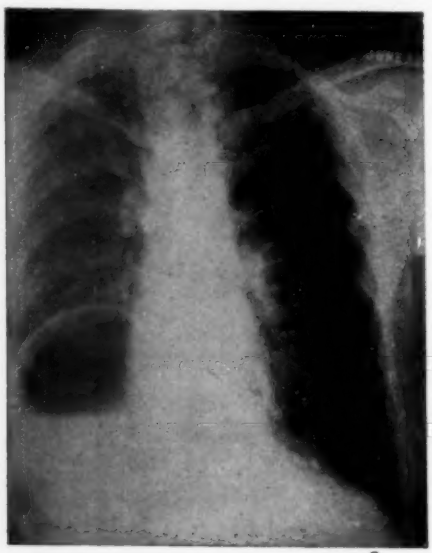

FIG. 1.

FIG. 2.

A routine *x*-ray examination of the chest (Fig. 1) disclosed it as normal for a man of his age, with the exception of the shadow in the lower left thorax.

This shadow at first was thought to be a pneumothorax, or possibly a diaphragmatic hernia. To make the differential diagnosis the patient was given a barium meal; the two-meal method was employed.

FLUOROSCOPIC EXAMINATION.

The patient is tall and slender; the intercostal angle is somewhat less than a right angle; he approaches the asthenic type.

Standing Position.—The upper thorax is negative; the lower right thorax is also negative. Occupying the lower left thorax there is an area of high light which extends up into the thorax from below as high as the third interspace in front and ninth rib behind. This area is bounded by a definite thin line extending from the spine almost to the lateral wall of the thorax. It is roughly pear-shaped in outline. On inspiration the right dome of the diaphragm moves down readily; the left cannot be made out with certainty. On the left side, on inspiration, there is definite movement of the splenic flexure upward, but the area of high light changes very little. It tilts somewhat and slightly flattens. This is suggestive of a "paradoxical respiratory phenomena.[3]" The shadow of the heart and lower bronchovascular tree can be seen through this area. In the lateral position this area is somewhat posterior to the heart.

The cecum, transversus and splenic flexure, except for high position, are normal. The splenic flexure lies very close to the area but is below it.

The esophageal function is normal. The barium enters the stomach just below the medial margin of this area of high light. It splashes upon its inner surface and drains

out immediately into the middle portion of the stomach. There is a definite constriction just below the fundus (as this area is now identified) between the upper and middle thirds of the stomach (Fig. 2) through which the barium trickles down into the pars pylorica. The stomach canalizes readily below the constriction. The greater curvature is on a level with the crests (Fig. 3). The cap is triangular and normal in outline. Pressure on the redundant pyloric antrum forces the barium back up through the constriction.

FIG. 3.

FIG. 4.

Dorsal Position.—In this position the area of high light is completely filled with barium. It is definitely pear-shaped in outline; the smaller end is about one inch from the spine.

Prone Position.—In this position the area is well filled, but the pear shape is not so apparent. The whole of the stomach lies to the left of the spine and its position from this point of observation has moved to upper part of abdomen. Contraction waves pass readily over the prepyloric region (Fig. 4). As the patient is gradually raised to an upright position the fundus empties, the level of the barium becomes horizontal and it can be seen to enter the prepyloric antrum below, through the constriction. The left dome of the diaphragm cannot be positively identified.

There was no retention. At the end of three hours the stomach was entirely empty and after twenty-four hours the gastrointestinal tract was practically empty.

From the above examination there is little doubt as to the condition found. The clear area in the lower left thorax is the fundus of the stomach, above the left diaphragm. It is probably fixed around its outer surface since it did not change its size or shape or collapse during any manipulation or change of the patient's position. Observations were made with the patient in all possible positions. Probably the opening in the diaphragm through which the stomach passes is just to the left of the hiatus esophagus.

The condition was at first thought to be congenital, but on more careful inquiry it was decided that it probably followed a blow on the abdomen when the patient was about thirteen years old.

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HERNIA OF THE DIAPHRAGM WITH A PORTION OF THE STOMACH IN THE THORACIC CAVITY

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Late Capt. M. C., U. S. A., Roentgenologist, General Hospital 41

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PRIOR to the great war, cases of hernia of the diaphragm with either the stomach or colon or both passing into the thoracic cavity were a decided rarity. In fact, in 1908 the most recent text-books did not even mention the images furnished by this type of lesion. Barjon mentions a single case in which the diagnosis was doubtful—either pneumothorax with double pocket or a hernia of the stomach in the chest.

In addition, we have mentioned in a chapter by Patel and Jaboulay on hernias in "Nouveau Traité de Chirurgie de Le Deutre et Delbet," Paris, 1918, this type of lesion, and a case of congenital hernia of the diaphragm with the stomach in the thoracic cavity reported by Dr. L. T. LeWald of St. Luke's Hospital,, New York, in THE AMERICAN JOURNAL OF ROENTGENOLOGY in 1917. Also one reported by Berti and Giavedoni in an article published in Milan in 1916.

Since the war, in addition to the case described by Jean Quinn and Legrain, which was revealed by autopsy, a case of diaphragmatic hernia of the stomach and transverse colon has been reported by Dr. Pierre Wairt in *Bull. de la Soc. de Chirurgie de Paris,* Vol. XLIII, No. 25, July, 1917. There have also been two observations of P. Lecine in the *Journal de Chirurgie,* Vol. XIV, No. 3. All these depended upon the radioscopic examination.

Another case has since been reported in the *Journal of the American Medical Association,* July 26, 1919. There are in addition two cases, which have been reported by Dr. P. Aimé and Dr. J. Solomon, the article appearing in THE AMERICAN JOURNAL OF ROENTGENOLOGY, August 1919, also a case by Andrew J. Grant in the *British Med. Jour.,* Sept. 27, 1919.

There are two cases which were observed by Major Martin, and the anatomical specimens are in the Museum of the Val de Grace.

Most writers agree that the roentgen examination is diagnostic in these cases, but granting for the sake of argument that the above is claiming too much, and that the clinical signs and symptoms are sufficient for the diagnosis, still all are agreed that the roentgenoscopic examination gives the clinician a factor of certainly that he should never neglect.

It must be admitted that the term "Hernia" which is in general use for this lesion is to use Lecine's words "partially exact." He prefers "transdiaphragmatic interpleural evisceration" because there is no hernial sac. However, the term is used generally and with good authority to such organs as the brain.

The mechanical cause, namely: The difference between the inter-abdominal and the inter-thoracic pressure in inspiration or in caughing, is sufficient to cause the passage of the abdominal viscera to a certain extent into the chest, when the diaphragm has either a traumatic or congenital break in its continuity. The stomach is the abdominal organ most commonly associated with hernia.

The clinical signs described by Patel and Jaboulay are dyspeptic symptoms, vomiting, angioid pains, tympany on percussion, borborygmus and gurgling with auscultation. These symptoms are usually vague or incomplete, a number being very obscure and showing no clinical symptoms, being autopsy findings.

This was somewhat true in the case which the writer wishes to report.

Case B. Cook. Second Anti-Aircraft Bat. was admitted from Evacuation Hospital to French Hospital No. 46 with a gunshot wound in his left chest posteriorly and multiple wounds in his left thigh. On December 5, 1918, patient was admitted to Base Hospital No. 1. The gunshot wound in his left chest was healed. A foreign body was removed by a posterior incision of the chest and the operative wound healed rapidly and without complication. At this time expansion of lung resonance and breath sounds apparently normal. All wounds of thigh partly healed. Patient slightly jaundiced.

On December 18th, patient complained of weakness. Heart action rapid and examination of the chest showed function of the left lower lobe considerably impaired from the wound. On December 22, 1918, patient weak and complaining of pain in epigastric region. Temperature 99 degrees. On December 27, patient to be evacuated to Base Hospital, free of hernia, no evidence of uremia. December 30, entered Base Hospital No. 100, Savonary, France, in weak condition; complaining of heartburn and vomiting. December 30, condition slightly improved. Still unable to retain nourishment. Vomiting after meals, usually one to one and one-half hours. Apparent pallor, some emaciation, not jaundiced.

January 28, 1919, general condition improved. Still vomits and has epigastric distress. Ready for evacuation to United States.

Admitted to General Hospital No. 41, New York, February 28, 1919.

Physical examination reveals scar extending diagonally from below, upward from posterior axillary line to within 10 cm. of 6th dorsal spine. Breath sounds clear and frequently absent below scar on left side. Here also note on percussion is dull and vocal fremitus absent. Abdomen scaphoid. Tenderness in epigastrium and right hypochondriac region. Patient shows pallor; no jaundice; is emaciated and complains of heartburn and constant pain in abdomen. Vomits after every meal a portion of the meal. *X*-ray examination of the chest requested.

February 23, 1919, when the roentgen examination was made the patient was first examined by means of a plate while in the prone position, the negative showing a resection of about 7 cm. of the tenth rib posteriorly. In this region, extending from the lower border of the eighth rib was a large rounded mass, showing a diffuse hazy increase in density, but a clear area was noted in the costodiaphragmatic angle. The upper border of this area had a definite sharply marked outline which was convex. (Fig. 1.)

FIG. 1. SHOWS SHADOW IN CHEST WHICH PROVED TO BE POUCH OF STOMACH ABOVE DIAPHRAGM.

When fluoroscoped in the prone position these findings were confirmed. This of course suggested the possibility of encapsulated fluid in the lower portion of the left chest. The patient was then fluoroscoped in the erect position and what previously had appeared to be a sharp outline of the upper border of the area of increased density, was seen to be a definite line convex upward, and below this line a very sharp clearly marked fluid level was seen. This fluid was seen to pulsate with the pulsation of the heart. The fluid line changed with a change of position of the patient and continued to transmit the cardiac pulsations. The cardiac shadow was slightly displaced to the right. The left lung was forced upward and contained less air than the right. On deep inspiration there was

a definite lagging of the left side of the chest; the interspaces did not change to as great a degree on the left as on the right, and the convex line in the lower portion of

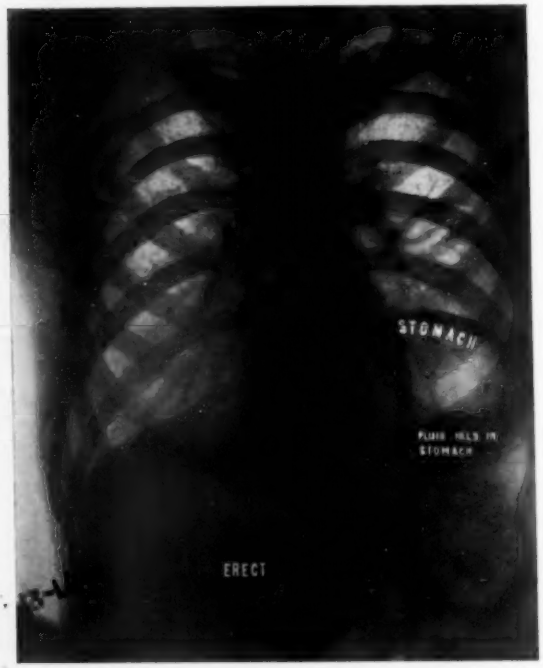

FIG. 2. SHOWS PATIENT STANDING WITH UPPER BORDER OF STOMACH AS CONVEX LINE AND A FLUID RETAINED IN STOMACH.

the chest remained stationary. This convex line appeared to be about the level of the eighth rib. A plate was then made with the patient erect and these findings confirmed. (Fig. 2.)

The patient was then fluoroscoped while drinking Barium Sulphate in buttermilk. The opaque meal passed down the esophagus normally, passing through the cardia and entering the stomach in the median line. As the barium filled the stomach a sacculated shadow appeared to the left of the median line. This shadow of the barium did not fill the stomach in the usual position in the abdomen but formed a pouch to the left of the median line and then passed upward through a constricted portion. (Fig. 3.)

As the patient continued to drink the Barium the pouch in the abdomen grew larger and the opaque substance was seen to pass more readily through the constricted portion and then fill another pouch above the first. As this took place the fluid line in the thorax was seen to rise definitely until it merged with the convex shadow in the left chest. (Fig. 4.)

Twenty-four hours after this examination all of the barium had passed out of the stomach and only a small amount remained in the descending colon and rectum. The examination of the chest at this time showed that the upper pouch of the stomach still contained barium and revealed a fluid level still present in the chest; the findings being exactly similar to those seen in the previous examination of the chest with the patient in erect position, as shown in Fig. 2.

From these findings the diagnosis was made of hernia of the diaphragm with a

FIG. 3. SHOWS BOTH POUCHES OF STOMACH FILLED, UPPER ONE BEING ABOVE THE DIAPHRAGM AND ALSO THE CONSTRICTED PORTION IN THE DIAPHRAGM OPENING.

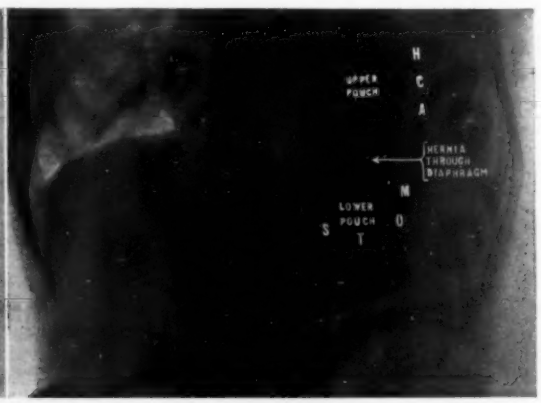

FIG. 4. SHOWS LOWER POUCH FILLED AND BEGINNING FILLING OF UPPER POUCH.

portion of the stomach in the thoracic cavity.

These observations show the tremendous importance of a roentgen examination, not only from a diagnostic standpoint, but also to alleviate the suffering of the patient in all such obscure stomach and chest conditions, and to give the surgeon definite information for operative intervention.

The writer cannot be too emphatic on this point and agrees heartily with Drs. Aimé and Solomon in their observations published in THE AMERICAN JOURNAL OF ROENTGENOLOGY, August, 1919. The interesting pathological findings are that wounds of the diaphragm show a necessity for surgical intervention, having no tendency to spontaneous healing. This is proven by the fact that this patient had been under observation for three months without change in his condition. It also proves that the clinical signs and symptoms of hernia of the diaphragm and the clinical methods of diagnosis are at the best very indefinite.

A report of one case would certainly not be of value in proving the above, but when taken into consideration along with the cases reported by other roentgenologists it is confirmatory, especially in view of the fact that several cases have since been reported which are exactly similar as to clinical signs and proving that spontaneous healing never occurs any more than would a case of femoral or inguinal hernia.

MANUFACTURE OF THE COOLIDGE X-RAY TUBE

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IT was the privilege of the General Electric Company to entertain the members of THE AMERICAN ROENTGEN RAY SOCIETY and guests during the meeting at Saratoga Springs in September, 1919, and to show them by a trip through the laboratory and factory the various processes involved in the manufacture of the Coolidge *x*-ray tube. It is obviously impossible to convey by a written description the impressions gained by a personal inspection of this sort, but for the benefit of those who were unable to be present at that time, the following brief record is offered.

The Coolidge *x*-ray tube is now manufactured in two different types, Universal and Radiator. (For a description of these and their mode of operation, the reader is referred to various publications which have been issued during recent years.[1])

The process of manufacture of this tube may be divided into the following steps:

1. Preparation of the Metal Parts.
2. Assembly of the *X*-Ray Tube.
3. Exhaust of the Assembled Tube.
4. Testing *X*-Ray Tubes.

1. PREPARATION OF THE METAL PARTS.

TUNGSTON.—Wrought tungsten is one of the essential metals entering into the construction of the anode and cathode of all of the above types of Coolidge tube. The complicated process required for the production of this metal was evolved in the Research Laboratory in connection with the incandescent lamp development. The steps involved are as follows:

(a) *Purification of Tungstic Oxide.* Commercially pure tungstic oxide powder is dissolved in strong aqueous ammonia, and the solution is filtered. Pure tungstic oxide is then very carefully precipitated from this solution by the addition of hydrochloric acid. This yellow precipitate is filtered, very thoroughly washed, dried in oven at about 300°C., and finally sifted through 40 mesh sieves. A very high degree of purity is required in the oxide in order that the tungsten metal produced from it may be workable in the later stages of the process.

(b) *Reduction of Tungstic Oxide.*—The purified tungstic oxide is reduced to tungsten metal powder by means of hydrogen in a battery of specially designed reduction furnace (Fig. 1). These furnaces consist of electrically heated porcelain tubes in which a definite amount of the oxide is placed, and through which dried and purified hydrogen is passed at a definite rate. The temperature of the furnace is very gradually raised and maintained at a maximum until the reduction is complete. The metal is then allowed to cool in the atmosphere of hydrogen before removal from the furnace. The whole operation requires about twenty-two hours, and every step must be very carefully regulated in order that the resulting metal shall have the necessary characteristics.

(c) *Pressing Rods of Tungsten Powder.*—The resulting metallic powder is pressed into rods in the following manner (Fig. 2). A weighed amount of the dry tungsten powder is formed by hydraulic pressure in a specially designed mold into a rod 11 inches

[1] A Powerful Roentgen Ray Tube with a Pure Electron Discharge. *Physical Review*, Vol. 2, No. 6, December, 1913.

A New Radiator Type of Hot Cathode Roentgen Ray Tube. *General Electric Review*, January, 1918.

The Radiator Type of Tube. AM. J. ROENTGENOL., Vol. 6, No. 4, April, 1919.

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Coolidge *X*-Ray Tube. Instruction Book 9136A, General Electric Company, April, 1919.

long, 1 inch wide and 1 inch thick. In the operation, a force of over 100,000 pounds is applied to the plunger of the mold. The pressed rod thus produced is too fragile to pick up, but is carefully transferred to a temporary support, consisting of molybdenum, the sister element of tungsten. On this support, the tungsten rod is heated of a current of 10,000 amperes at 6 volts (60 KW). (Fig. 3.) In this "treating bottle" the rod is protected from oxidation by a steadily maintained current of hydrogen gas. The interesting features of the treating bottle are the upper water-cooled clamp, the heavy copper lower clamp swimming in a water-cooled pool of mercury which leaves

FIG. 1. FURNACES FOR REDUCING TUNGSTIC OXIDE.

three-quarters of an hour at about 1600°C. in an electrically heated tube furnace, and is protected from oxidation at this temperature by hydrogen gas, which is continually passing through the furnace. In this firing operation, the rod shrinks from 11 inches to 10½ inches in length and becomes strong enough to be handled.

(d) *High Temperature Sintering of Tungsten Rods.*—A tungsten rod pressed and fired as just described is next clamped in an upright position in a so-called "treating bottle" in which it is heated close to its melting point for about an hour by the passage the rod free to shrink, and the mercury seal which prevents air from reaching the interior of the bottle.

As it comes from the "treating bottle," the tungsten rod is very dense, is brittle when cold, and gives a fracture resembling steel.

(e) *Hot Swaging of Large Tungsten Rods.*—Tungsten cannot be worked mechanically while cold. It is so hard that it cannot be machined by sharp edge tools, but has to be brought into desired shapes by high temperature hammering or cold grinding.

The rough anode head for the Universal

tube is formed from a sintered tungsten rod in a swaging machine, which is a nicely controlled high speed hammer used in this case to reduce, by successive operations, the diameter of the tungsten rod. The rod is heated to about 1600°C. in an atmosphere of hydrogen gas in an electric furnace, and is then rapidly passed through the swaging machine. In this operation the diameter of the rod is reduced 10 per cent. The rod is then re-heated in the furnace and is ready for the next pair of swaging dies, which will again reduce its diameter by 10 per cent. When the rod is at the required diameter for the head of the anode, the end of the rod only is swaged down to form the taper and straight portion to which the molybdenum stem is attached. After rough grinding to approximate size and shape, the anode head and molybdenum stem are swaged together. The assembly is completed by the addition of an iron collar and a thin metal tube and the finished anode is then polished and very carefully cleaned.

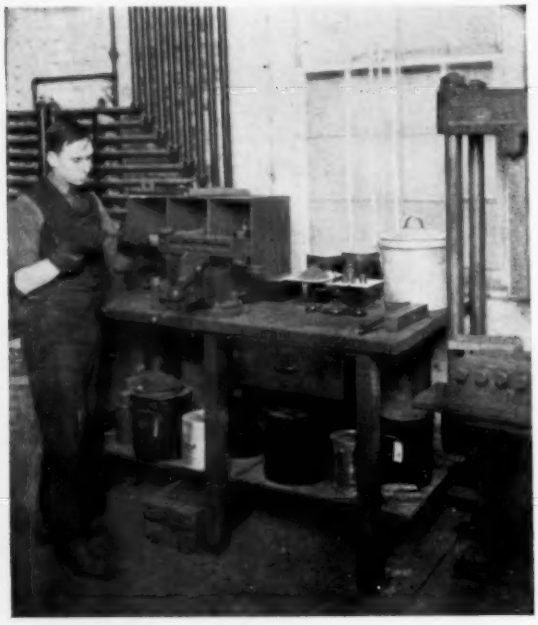

FIG. 2. MOLD AND HYDRAULIC PRESS FOR MAKING RODS FROM TUNGSTEN AND MOLYBDENUM POWDER. The operator is removing a rod from the mold after pressing in the hydraulic press at the right.

(f) *Tungsten Wire for Cathode Filaments.*—The tungsten wire used in making the filament for the cathode is produced in a similar manner, the rod being reduced in size in the swaging machine until it may be hot drawn to the required size of wire through diamond dies.

MOLYBDENUM.—Wrought molybdenum is very much like wrought tungsten, but differs from it in that it can be machined while cold. Also for a given amount of mechanical working, it is stronger than wrought tungsten. Various parts of the cathode and anode structures are made from it. Its preparation is similar to that of wrought tungsten.

FIG. 3. TREATING BOTTLE AND TRANSFORMER FOR SINTERING TUNGSTEN AND MOLYBDENUM RODS. The operator is lowering the bottle over the rod which is held in place by the heavy copper clamp.

COPPER-BACKED TUNGSTEN ANODES.—The anodes for radiator type tubes are made by casting specially purified (boronized) copper around a carefully cleaned tungsten disc in a vacuum.[2] Copper and tungsten do

[2] COOLIDGE. Metallic Tungsten and Some of Its Applications. *Trans. Am. Inst. Elect. Engrs.*, 31 (1), 1219-28, 1912.

not alloy with one another, but under the conditions employed, the melted copper wets the tungsten and adheres firmly to it when it solidifies. This process assures good thermal conductivity between the tungsten and the copper. The finished anode heads are electrically welded to a rod of copper which is to extend out through the anode arm of the tube and support the radiator. The platinum or alloy sleeve by means of which the seal between anode and glass is made is silver-soldered to the copper rod.

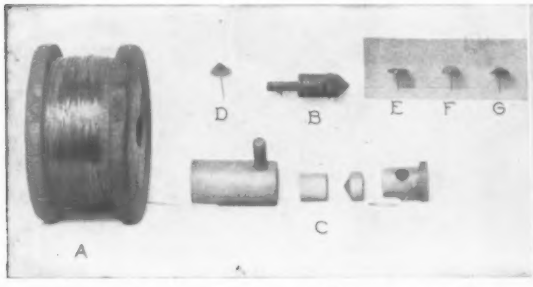

FIG. 4. VARIOUS STEPS IN THE FORMING OF FILAMENTS FOR CATHODES. *A*, spool of tungsten wire; *B*, Mandrel with filament wound on it; *C*, form (unassembled) for high firing of filament; *D*, low fired filament; *E*, fine focus filament after firing in form; *F*, medium focus filament; *G*, broad focus filament.

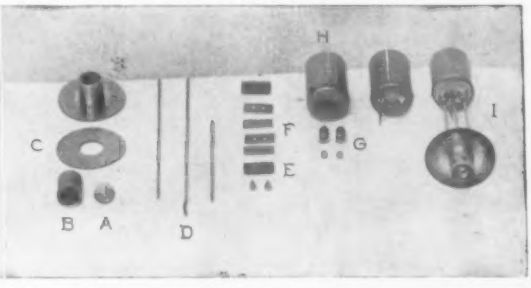

FIG. 5. PARTS OF CATHODE OF UNIVERSAL TYPE TUBE AND VARIOUS STAGES OF ASSEMBLY. *A*, filament; *B*, molybdenum tube; *C*, molybdenum disc; *D*, leads; *E*, metal clamp; *F*, mica washers; *G*, bushings; *H*, support tube; *I*, assembly.

CATHODE ASSEMBLY.

(a) *Preparation of Cathode Spirals.* For all cathode filaments, tungsten wire of 0.0085 inch diameter is used. The first operation in making a filament spiral is the winding of the wire on a conical mandrel of special tungsten steel. Before the spiral is removed from its mandrel, it is given an anneal in hydrogen in an electric furnace. Conical spirals thus prepared are next clamped in molybdenum forms and heated in an electric furnace to a temperature of 1600°C. in an atmosphere of hydrogen gas. This forming of spirals is carried out to give three different shapes of filament which are necessary to produce the various sizes of focal spot (Fig. 4).

(b) *Assembly of Cathodes.*—The assembly of the cathode calls for very delicate manipulative work. As shown in Fig. 5, many of the parts are small; and in order to obtain the desired size and distribution of energy over the focal spot, the relative positions and shapes of these various parts must be nicely regulated. The tungsten terminals of the spirals in assembled cathodes are welded in place by arcing in hydrogen gas. One weld is made on the cathode cup and the other on the metal leading-in wire. This operation is carried out in an inverted glass bell jar through which is passing a stream of hydrogen.

VACUUM FIRING OF METAL PARTS.—All metal parts before being mounted in an *x*-ray tube are fired in a quartz tube vacuum furnace at 900°C. for about an hour, and are allowed to cool down in a vacuum so as to prevent oxidation (Fig. 6). The purpose of this firing is to render the parts perfectly clean and to remove partially the occluded gases and thus reduce the time required in the exhaust of the tube.

2. ASSEMBLY OF *X*-RAY TUBE.

The bulbs and glass parts used in the tube are blown in molds at the glass factory and are therefore of uniform shape and quality.

The operation of assembling these glass parts and the metal parts prepared as above is carried on by girls with the help of glass-blowing machines, one of which is shown in Fig. 7. These are essentially lathes in which

the two glass parts to be joined are clamped in separate chucks which are geared together so as to rotate at the same speed. Fires are provided for melting the glass, and compressed air, controlled by valves, for blowing.

high degree of vacuum for successful operation, approximately one ten-millionth of an atmosphere. In order to obtain this high vacuum, an elaborate exhaust system is necessary, as shown in Fig. 8. This consists of a series of three mechanical pumps, one con-

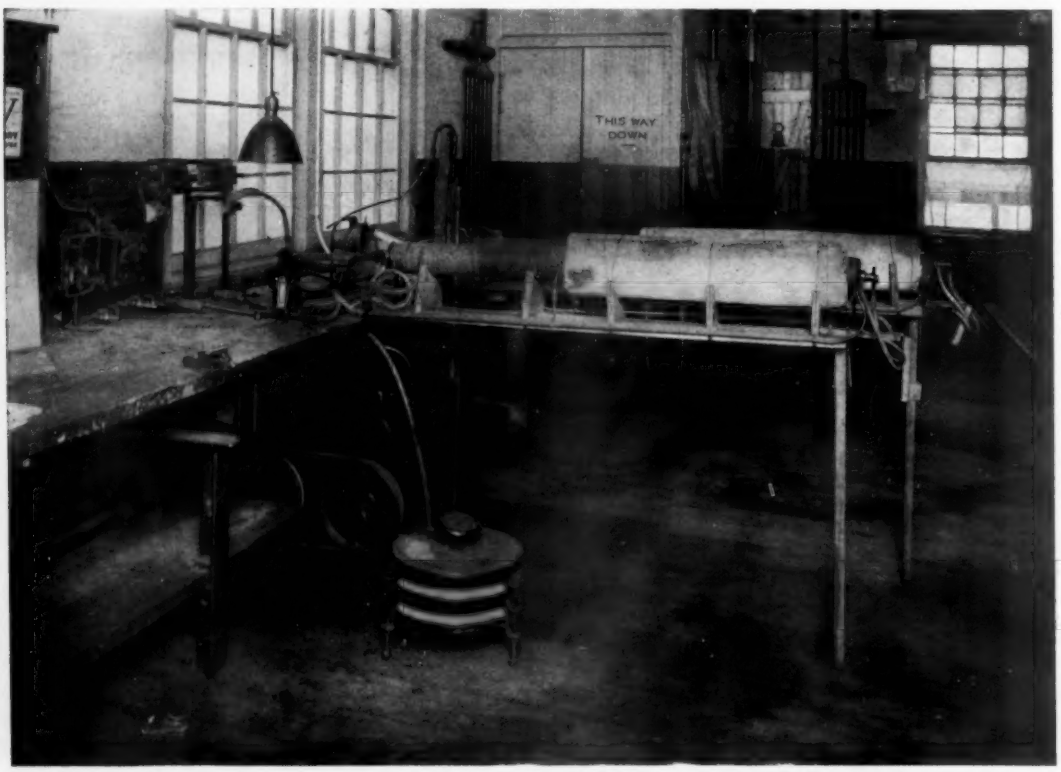

FIG. 6. VACUUM FURNACE USED FOR FIRING METAL PARTS OF X-RAY TUBES.

The various steps involved in the assembly of the tube are as follows:

a. Sealing on exhaust tube.
b. Sealing on cathode side arm.
c. Sealing in anode support tube.
d. Sealing in anode.
e. Sealing in cathode.

A separate machine is used for each of these operations, each one being slightly different from the others.

There are a few operations, especially in the assembly of the radiator type tubes, which require the services of skilled glass-blowers.

3. EXHAUST OF THE FINISHED TUBE.

The Coolidge *x*-ray tube requires a very

densation pump, and a trap surrounded by liquid air.

The *x*-ray tube to be exhausted is sealed directly to the glass tube coming from the liquid air trap. It is supported inside of a large oven, which is arranged with electric heaters for heating the tube during the first stage of the exhaust, and so constructed as to provide ample *x*-ray protection for the operators (Fig. 9).

The first operation in the exhaust consists of heating the tube to about 400°C. for three-quarters of an hour. This heating removes water-vapor, carbon dioxide and other gases from the glass and metal parts.

After cooling, the tube is connected to an *x*-ray machine and operated as an *x*-ray tube. For the early stages of the exhaust, a

machine is used which is so arranged that it operates automatically, passing just enough current through the tube to drive out the gas at a rate at which it can be removed by the exhaust system. The final stages are carried

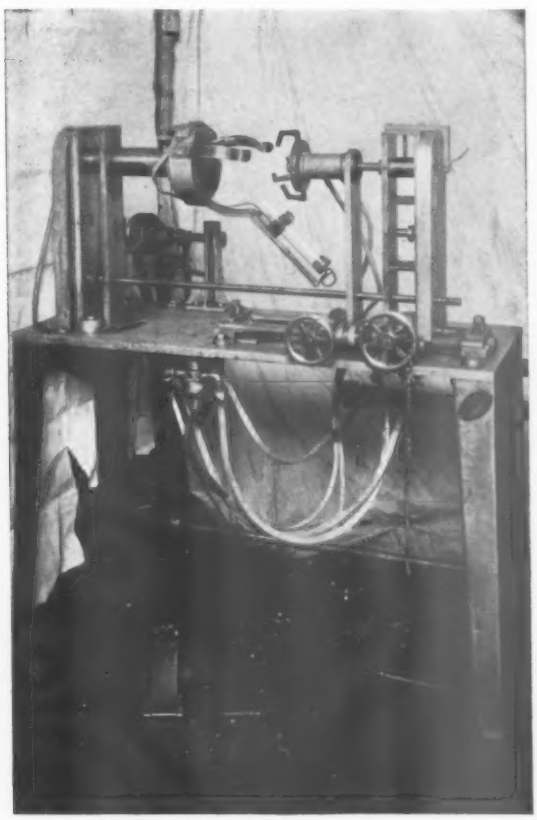

FIG. 7. GLASS-BLOWING MACHINE.

out on a regular interrupterless machine, and the operation has to be very carefully regulated by trained operators. As the vacuum improves, the potential applied to the tube is constantly raised. The operation is continued until all signs of gas, that is, appreciable green fluorescence in the bulb, have disappeared and the tube is backing up a 10 inch parallel spark gap and the anode is at an intense white heat. The whole operation requires about one and a half to two hours' time.

The above description applies to the exhaust of the Universal type of tube. The anode in the radiator types of tube cannot be heated as hot because of the low melting point of copper. The exhaust is carried out with the tubes connected to high tension transformers without mechanical rectifiers and requires a considerably longer time than the Universal type.

4. TESTING *X*-RAY TUBES.

A. UNIVERSAL TYPE. *When the exhaust* of the tube is completed, it is sealed off from the exhaust system. After an interval of at least twenty-four hours, it is given a preliminary test. This consists of running at a six inch parallel spark gap with sufficient current through the tube to heat the anode to a white heat, and then increasing the gap to ten inches. Tubes which show appreciable green fluorescence in the bulb are rejected and must be re-exhausted. Tubes which pass the first test are provided with anode and cathode bases, and after a certain time-interval given a second test which is a duplicate of the first. A third test is made just before shipment.

B. RADIATOR TYPE. (a) *10 Milliampere Tube.*—The test of the radiator type tube differs considerably from that of the Universal type. The preliminary test of the 10 milliampere tube consists in running for two minutes with 5 milliamperes at 40 KV., one minute with 5 milliamperes at 50 KV., and one minute with 10 milliamperes at 60 KV.

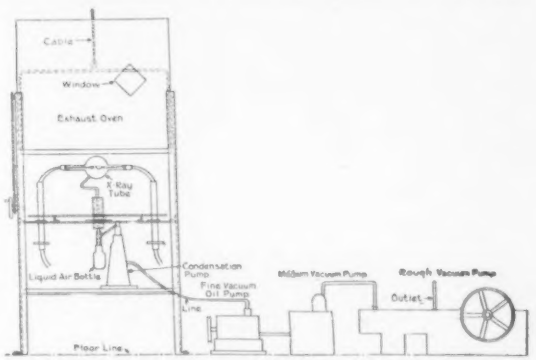

FIG. 8. OVEN AND EXHAUST SYSTEM FOR EXHAUSTING *X*-RAY TUBES.

After basing and after a certain time-interval, the tube is given the second test, which consists of running continuously for two minutes at 10 milliamperes and 60 KV.

Tubes are rejected which show appreciable green fluorescence in the bulb.

During the two minute run, three pinhole camera focal-spot pictures of the tube are made on a dental film. Two of these are made with differently timed short exposures and show the distribution of the energy over the focal spot. The third is made with a longer exposure to show the total area of the focal spot. This third focal-spot picture is very carefully measured along two diameters, and if the size does not fall within certain very narrow limits, the tube is rejected.

(b) *30 Milliampere Tube.*—The preliminary test is the same as that for the 10 milliampere tube. The second test consists of a twenty-five second run with 30 milliamperes and 60 KV. Focal spot pictures are taken during this run.

(c) *Dental Tube.*—The first test is similar to that of the 10 milliampere tube except that the highest voltage used is 50 KV. The second test consists of a two minute run with 10 milliamperes at 50 KV., during which time focal spot pictures are made.

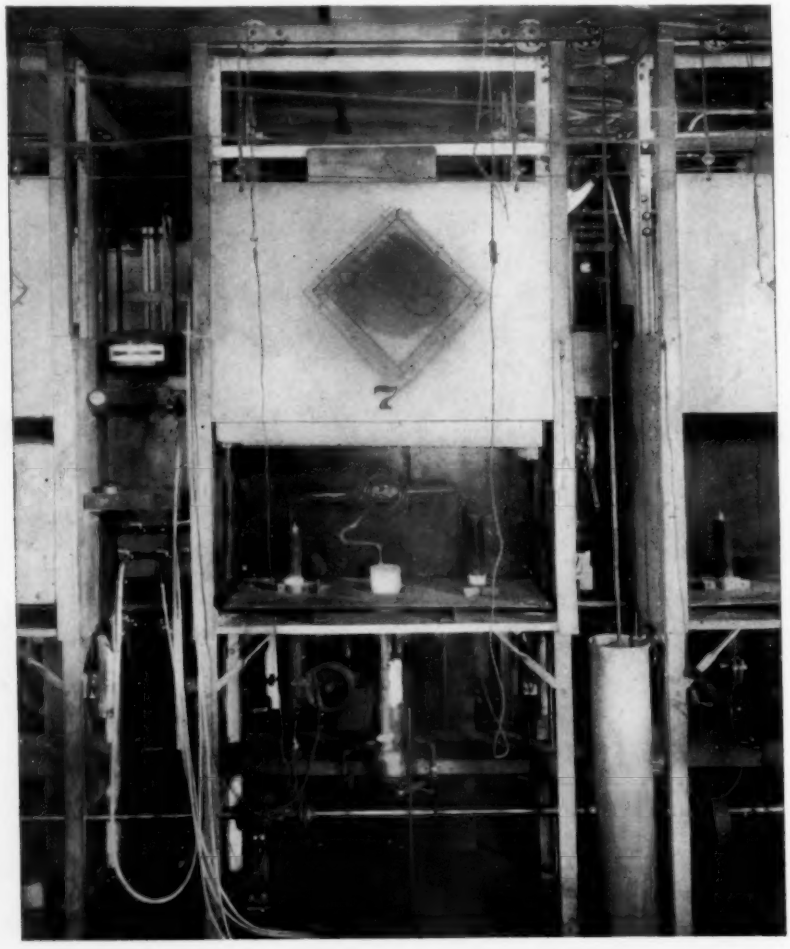

FIG. 9. EXHAUST OVEN FOR UNIVERSAL TYPE TUBE WITH TUBE IN POSITION.

(d) *Portable Tube.*—The first and second tests consist of running the tube on the portable outfit for fifty-five-second shots with 10 milliamperes at 60 KV. with two-second intervals between consecutive shots.

Tubes are usually held in stock for several days after testing, and they are finally given a short test and are then crated for shipment.

A STUDY OF GAS-CONTAINING ROENTGEN RAY TUBES AND A DESCRIPTION OF A NEW TUBE

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INTRODUCTION

THE unstable vacuum of the gas-containing *x*-ray tubes and the final failure of the usual regulators have always been troublesome features. After considering the various theories supposed to account for these difficulties, the tube here described was constructed in the hope of securing a more stabilized vacuum and of supplying a regulator which would give at once better control and longer life to the tubes.

Kaye [1] states: "Systematic work is needed to find the most suitable gas for an *x*-ray tube. Unless precautions to the contrary have been taken, the gas will probably consist largely of hydrogen and carbon dioxide liberated from the electrodes. Platinum and especially aluminum (and magnesium) emit large quantities of gas when used as cathodes. This point is also of importance in connection with the various methods of controlling the hardness of bulbs. The automatic devices introduce, chiefly, carbon dioxide and, in some cases, a little water vapor; the osmosis valves, hydrogen; the Bauer valve, air. So far as sputtering goes, hydrogen and carbon dioxide would appear to have advantages, though there is some diversity of opinion on this point. On the other hand, it may be remarked that a tube rendered unsteady by the hardening effect of hydrogen may often be caused to run smoothly by letting in a little air."

In view of the fact that very little experimental work has been done on this subject, and because of the inherent advantages arising from the ability to control and run continuously and uniformly the gas-containing roentgen ray tube with its valuable properties, the investigation, reported in the following article, was undertaken with the object of studying:

1. The nature of the equilibrium between the residual gases, the metals of the electrodes, and the glass walls of the gas-containing roentgen ray tubes used at present.

2. The nature of the process of seasoning through which greater constancy of vacuum is obtained when the electrodes are heated by the passage of current through the tube.

3. The behavior of different homogeneous gases in contact with the metals and the glass wall of the tube when these are heated to higher temperatures.

4. The nature of the action of the vacuum regulating systems commonly employed and the effects of their use upon the vacuum and the properties of the tube.

5. Experiments with a new gas and a new regulating substance; also a new type of regulator and the results obtained therewith.

THE ADSORPTION OF GASES BY SOLIDS; REPORT OF EXPERIMENTS

In an attempt to explain the process of adsorption between substances in different phases, particularly of solids and gases, F. Haber [2] expounded the theory of the structure of solids and crystals which is based on the experimental work of Laue and Bragg on *x*-ray spectra. He concluded that solids are bound together by the valence forces of the atoms which hold them in a regular arrangement or pattern. But since there is no evidence that atoms are differently arranged at the surface than in the interior, there must be free and unoccupied valences at the surface of the solid reaching

[1] KAYE, G. W. O. 1917, *X*-Rays, page 83.

[2] HABER. 1914. *Zeit. f. Elektroch.* 20, 521.

out into space, and these valences, which are distinctly chemical in nature, account for the phenomena called "adsorption" phenomena. Because of the existence of valence forces at the surface of a solid, finely divided substances like palladium and nickel due to their large surface are capable of adsorbing large volumes of gas. The adsorption combination, however, has the property of being generally less stable at higher than at lower temperatures, i.e., if an adsorption complex is heated it splits up or dissociates into its component parts.

As is rendered evident by the manner in which ordinary roentgen ray tubes act during operation, there are changes taking place in the relation between the metals and the gas during heating and cooling of the tube. The series of experiments described in the following were undertaken with the object of determining the relation of the metals to various gases both during the process of heating the system and during cooling for the purpose of discovering the gas which would be best suited as a residual gas for roentgen ray tubes.

In the following is given a short description of the apparatus employed, and the method of obtaining the results together with a tabulated report. The apparatus employed consists of a thin wall glass bulb

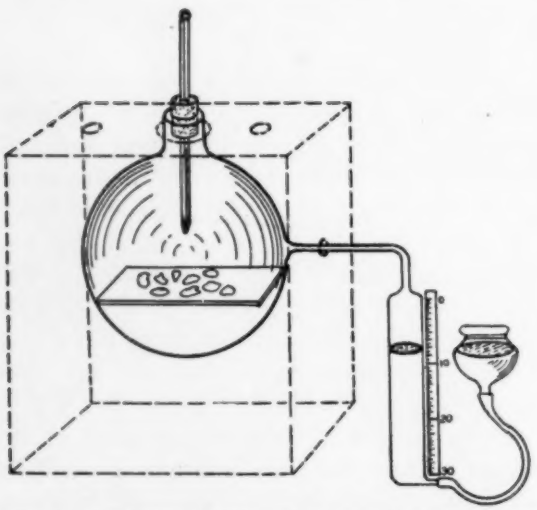

FIG. 1. APPARATUS EMPLOYED IN THE LABORATORY TO STUDY THE RELATION BETWEEN GASES AND METALS AT VARIOUS TEMPERATURES.

(capacity 407.40 c.c.) on which is sealed a narrow tube that is connected to a mercury manometer. At a distance of 45 degrees from this, is a larger opening, into which fits an asbestos stopper with a thermometer reaching some distance into the glass bulb. Into this glass bulb was placed a glass support upon which the metal pieces could be placed. This bulb was enclosed in an asbestos box so that only the two necks projected (Fig. 1).

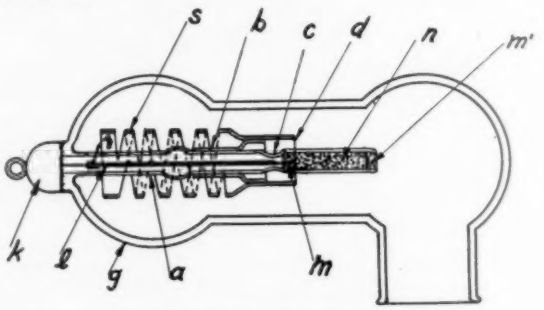

FIG. 2. THE NITROGEN VACUUM REGULATOR.

TABLE 1

Experimental data showing the absorption of *oxygen*, by iron, copper, aluminum and bismuth at temperatures varying from room temperature to 350 degrees centigrade and decreasing again to room temperature.

	Gas level measured downward at atmospheric pressure in the manometer tube at room temperature (cms.)				
Temperature Degrees Centigrade	*No Metal*	*15 g. Fe*	*15 g. Cu*	*15 g. Al*	*15 g. Bi*
18	0	0	0	0	0
50	4.5	4.0	4.0	4.0	4.0
100	9.0	8.5	8.0	8.0	8.0
150	13.0	12.0	11.5	10.5	11.0
200	17.0	15.5	14.0	13.5	13.0
250	21.5	18.0	15.0	16.0	15.0
300	25.0	20.0	16.5	18.0	16.5*
350	29.0	21.5	19.5	20.2	17.2*
300	25.0	18.5	16.5	17.5	16.0*
250	21.0	15.0	14.5	14.0	14.0
200	17.0	10.0	10.0	10.5	12.0
150	13.0	3.0	3.0	7.0	9.5
100	8.5	—	—	3.5	6.0
50	4.0	—	—	—	3.0
18	0	—	—	—	0

* Bismuth in molten condition.

The manometer employed consisted of a glass tube 4 cm. wide with a small side tube attached at the lower end. To this was con-

nected a rubber tube terminating in a large diameter glass container for the mercury. Behind the tube was placed a metric scale from which the differences in the gas volumes could be accurately read. The upper end of this tube was sealed to the small outlet communicating with the glass bulb. Readings were taken on a metric scale after the mercury levels were adjusted to the same height by raising or lowering the glass container connected with the tube.

The apparatus was filled in the following

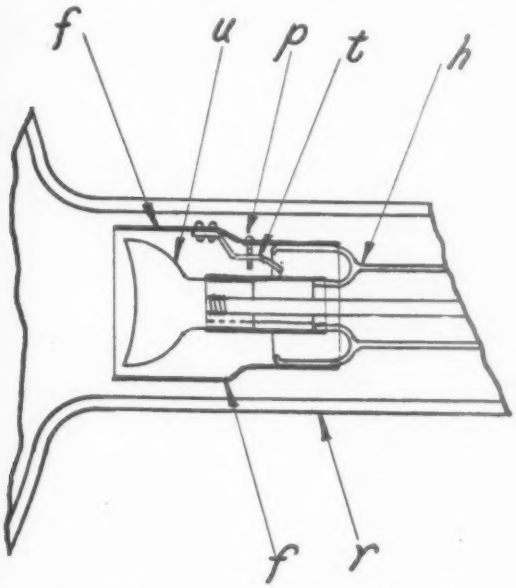

FIG. 3. PROTECTIVE SHIELD FOR CATHODE.

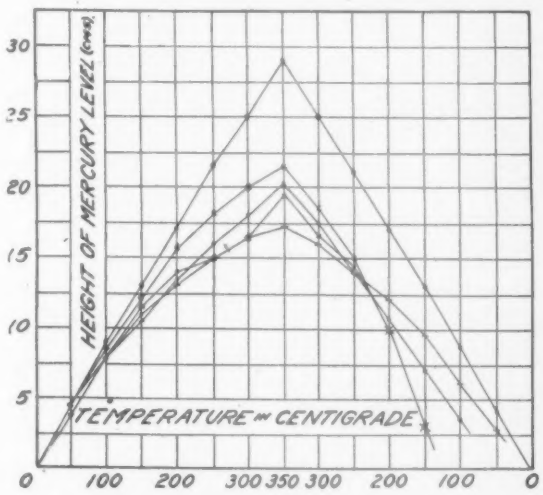

FIG. 4. CURVE I SHOWING THE CHANGES OF VOLUME OF OXYGEN WHEN AT VARIOUS TEMPERATURES.
o Oxygen without metal.
c Oxygen in contact with iron.
x Oxygen in contact with copper.
. Oxygen in contact with aluminum.
+ Oxygen in contact with bismuth.

TABLE 2

Experimental data showing the absorption of *hydrogen*, by iron, copper, aluminum and bismuth at temperatures varying from room temperature to 350 degrees centigrade and decreasing again to room temperature.

	Gas level measured downward at atmospheric pressure in the manometer tube at room temperature (cms.)				
Temperature Degrees Centigrade	*No Metal*	*15 g. Fe*	*15 g. Cu*	*15 g. Al*	*15 g. Bi*
18	0	0	0	0	0
50	4.5	4.5	4.5	4.5	4.5
100	9.0	8.5	8.5	8.5	8.5
150	13.4	12.0	12.5	13.0	11.6
200	17.0	15.0	16.0	16.5	15.2
250	21.0	18.2	19.3	20.5	18.5
300	25.0	21.5	22.5	23.5	21.0*
350	29.3	24.0	25.0	25.5	22.0*
300	25.5	20.0	21.3	22.5	21.5*
250	21.5	15.5	16.5	18.5	20.0
200	17.5	11.0	11.5	14.5	18.0
150	13.5	6.5	6.5	10.5	15.0
100	9.0	2.0	0.0	6.0	12.5
50	4.8	—	—	1.0	10.2
18	0.0	—	—	—	9.0

* Bismuth in molten condition.

TABLE 3

Experimental data showing the absorption of *nitrogen*, by iron, copper, aluminum and bismuth at temperatures varying from room temperature to 350 degrees centigrade and decreasing again to room temperature.

	Gas level measured downward at atmospheric pressure in the manometer tube at room temperature (cms.)				
Temperature Degrees Centigrade	*No Metal*	*15 g. Fe*	*15 g. Cu*	*15 g. Al*	*15 g. Bi*
18	0	0	0	0	0
50	4.5	4.5	4.7	4.5	4.5
100	8.8	8.5	9.5	8.5	9.0
150	13.0	13.0	14.0	12.5	13.5
200	17.5	17.5	18.5	17.0	18.0
250	22.0	21.5	23.0	22.00	22.0
300	26.0	25.5	28.0	25.5	25.5*
350	30.5	29.5	31.5	30.0	29.0*
300	26.0	25.5	27.5	26.0	25.5*
250	22.0	21.5	23.0	22.0	22.0
200	17.5	17.0	18.5	17.0	17.5
150	13.0	12.5	14.0	13.0	13.0
100	8.0	8.5	9.0	9.0	9.5
50	4.5	4.0	4.5	4.0	5.0
18	0	0	0	0	0

* Bismuth in molten condition.

manner: The gas generator delivering the purified and dried gas was connected to the lower opening of the measuring tube. For this purpose the mercury vessel was lowered until all the mercury had run out of the measuring tube; the rubber tube was detached and the entire vessel was turned upside down. A steady stream of gas was kept flowing until it could be assumed that all the air had been displaced. The vessel was then heated to bring the glass walls into equilibrium with the gas; the gas within the bulb was displaced by new gas and the process of heating was repeated. After having made certain that the residual gas was well in equilibrium with the glass walls, and being reasonably certain of the purity, the temperature curves given in Figs. 2, 3 and 4, the data of which are reported in Tables 1, 2 and 3, were obtained.

With this apparatus it was possible to reach the temperature of 350 degrees centigrade, and the experiments herein reported were performed between this and ordinary laboratory temperature of 18 degrees centigrade. The data obtained with the pure gases are in fair agreement with the values calculated from the gas laws. The slight decrease at higher temperatures is undoubtedly due to cooling where the gas comes in contact with the mercury of the manometer. After obtaining the normal temperature-volume curves for hydrogen, oxygen and nitrogen, the same curves were determined in exactly the same manner after successively placing 15 g. of one of the metals upon the glass support within the bulb. The curves obtained are plotted together with the normal temperature-volume curve for the three gases mentioned, and from the differences found the relation between the metal and the gas employed can be determined.

The metals selected for these experiments are copper, iron, aluminum, and bismuth. The samples were prepared in the following manner: The metal was disintegrated into fragments of about pea size with the object of creating large but nearly equal surfaces. They were then treated with dilute acid to remove all surface oxides and were washed quickly and dried in a desiccator. Before being placed in the apparatus they were placed in a smaller glass bulb connected to an ordinary water pump. The water pump was started and while this pump was maintaining a vacuum of about 1.6 cm. Hg., the metal was heated under the full blast of four Bunsen burners. After some time the pump was disconnected, the vessel closed and the metals allowed to cool. The metal pieces were placed as rapidly as possible upon the glass in the lower part of the experimental bulb. Without increasing the temperature of the bulb, the gas was allowed to flow through the vessel for a sufficient length of time to make sure that all foreign gases had been displaced. The apparatus was then closed by introducing the asbestos stopper with a thermometer, and connecting it to the manometer. The temperature was then slowly increased and an attempt was made to keep constant the temperature indicated by the thermometer in various steps so that an equilibrium reading was assured. At the steps given in the tables the temperature was kept constant for approximately 10 minutes. During the first three or four minutes, a gradual change in the volume could be observed, but during the remaining period for which the temperature was kept constant, no further change in the volume of the gas could be noted. That the condition of equilibrium existed was therefore rendered certain. After reaching a temperature of 350 degrees, cooling was brought about in steps so that every reading was again taken at full equilibrium, *i.e.*, with constant temperature and constant volume maintained for at least five or six minutes.

DISCUSSION

Plotting of the experimental data reveals interesting facts regarding the equilibrium between metals and gases. The curves show clearly, in the case of oxygen and hydrogen, that a considerable amount of gas is absorbed by the metals with the exception of bismuth. But in the case of nitrogen the quantity of gas absorbed is so small as to be negligible.

An interesting characteristic is shown by bismuth in that at high temperatures it shows a tendency to adsorb gases, whereas at low temperatures it shows a distinct tendency to release gases. This characteristic might lead to the suggestion that bismuth could be used in combination with the other metals, the characteristics of which are just the reverse, and would then give rise to a system maintaining a constant gas pressure at various temperatures. However, because of the very low melting point of bismuth (270 degrees centigrade) its melting and vaporization in a high vacuum could not be prevented. In spite of the apparent advantages of bismuth, therefore, its use as part of the electrodes of roentgen ray tubes is impossible.

The results of these experiments which are directly pertinent to the problem of constructing roentgen ray tubes can, therefore, be summarized as follows: The metals commonly employed in the construction of roentgen ray tubes, viz., iron, aluminum and copper, when heated to higher temperatures show the greatest chemical adsorptive affinity towards oxygen and hydrogen, and the least towards nitrogen. The assumption made at the start is, therefore, corroborated since nitrogen, because of its inertness as a chemical factor, shows the least tendency to combine with the electrode metals most commonly used, and, therefore, appears to be most suitable as a residual gas for roentgen ray tubes.

THE EQUILIBRIUM BETWEEN THE RESIDUAL GASES, THE METAL OF THE ELECTRODES, AND THE GLASS WALL.

The commonly employed gas-containing roentgen ray tube consists of a spherical glass bulb within which are placed the electrodes made of tungsten, copper and aluminum. These tubes are then evacuated while being heated in a furnace, in most cases, however, without taking the precaution to secure a homogeneous residuum, i.e., one consisting exclusively of one particular gas.[3] The vacuum, therefore, consists of attenuated air composed of approximately 20 per cent oxygen, 79 per cent nitrogen, 1 per cent carbon dioxide and noble gases. Water vapor, as a rule, is removed with a drying chamber containing P_2O_5 which is connected with the interior of the tube during the pumping.

Oxygen has great chemical affinity toward iron and copper and, if present in the tube, these metals combine with or release oxygen according to whether there is an excess or deficiency of this gas. When heated to higher temperature these compounds dissociate very readily, which fact accounts for the decrease in vacuum caused by the heating of the electrodes. Polyatomic gases such as carbon dioxide, water vapor, etc., when attenuated to an *x*-ray vacuum and subjected to bombarding the target of the tube when it is in operation, probably almost completely dissociate giving rise to a mixture of monatomic gases which, like oxygen, generally induce sputtering of the electrode metal, and then, by being adsorbed by the metal vapors, give rise to considerable variation in the gas pressure.

THE PROCESS OF SEASONING NEW TUBES

While it is not possible to follow experimentally the changes that take place within a tube during the process of seasoning, it is possible from known facts and given conditions to conclude rather definitely what processes are taking place. If tubes have been evacuated, then the presence of chemically active gases in these tubes indicates that all changes in vacuum are due to the release and resorption of chemically active gases when the temperature changes, and that during the process of seasoning there is formation of a more stable chemical union between the electrodes, or some sputtered metal, and the active gases. The final result is that the residuum ultimately must consist of the chemically most inert gases, i.e., those which show the least tendency to combine and interreact with the metals.

Assuming that oxygen and nitrogen con-

[3] Except in the case of the hydrogen tube.

stitute the bulk of the gas left in the tube, we can imagine the process of seasoning taking place in the following manner: A new tube coming from the glass blower, as a rule, is evacuated slightly more than is required. If current is passed through such a tube it will be found that the vacuum decreases slowly and this decrease is unquestionably due to the release of gas from the surface layers of the electrodes. If, after being heated to a considerable degree, the electrodes are allowed to cool, they readsorb gases, especially the more active oxygen; this, when the process is repeated several times, tends to penetrate deeply into the pores of the metal and enters into a more and more stable union with the metal.

The process of seasoning, in the given case, therefore, consists of the selective adsorption of the more active oxygen by the electrode metals, with the result that the more inert nitrogen finally is left to constitute the residual gas in the tube. Due to the inertness of this gas, there results from the disappearance of all other gases greater constancy in the degree of vacuum when the tube is heated, since there is no marked adsorption of nitrogen, as experiments show, nor chemical combination with the metals or the glass walls of the tube.

THE ACTION OF THE COMMONLY EMPLOYED VACUUM REGULATING SYSTEMS AND THEIR EFFECTS UPON THE PROPERTIES OF THE TUBE.

For the regulation of the vacuum of roentgen ray tubes a great variety of substances are employed. Such gases as hydrogen, air, moisture, carbon dioxide, etc., are introduced into the bulb with the aid of a heated tube of palladium to admit hydrogen, a small valve to admit a small volume of air into the bulb, or, by placing various substances in a side tube communicating with the body of the roentgen ray tube and heating them, the introduction of gases into the bulb is brought about. The substances commonly employed are charcoal, caustic alkalis, soda, lime, asbestos wool, etc. As a rule, these substances are heated by high tension current whereupon they liberate water vapor, carbon dioxide, hydrogen, etc. From the foregoing discussions, it is to be expected that the introduction of such gases brings the tube back to the initial condition of decreased stability of vacuum, since the adsorption of the chemically active gases has to be effected in each instance when the regulator is used. Again, there is the danger of overheating these substances by an excess of current causing over-reduction of the vacuum to such an extent that repumping of the tube may become necessary. Furthermore, after repeated use it may happen that the substance becomes exhausted, having yielded all its available gas. In such a case, it is necessary to open the tube, to change the regulating substance, and to re-exhaust it.

EXPERIMENTS

A New Gas.—The final design and method of evacuating a new type roentgen ray tube is based upon the reflections and experiments outlined in the preceding chapters. The new tube consists of the body of a roentgen ray tube constructed and designed according to approved principles.[4] Before sealing the electrodes into the bulb they are freed as much as possible from grease, oxides, dirt, etc. The tube is then filled with nitrogen gas (specific gravity .97) by displacing downward the air contained in it. The nitrogen gas is produced by a special chemical reaction which frees the gas from nitrous oxide, oxygen, hydrogen, or water vapor. When the bulb is thus filled, it is placed in a heating furnace and the temperature is increased gradually until the electrodes are a dull red. Under these conditions, the electrodes come into equilibrium with the nitrogen with which the bulb is filled in such a way that the oxygen and other gases originally occluded by the electrodes and the glass walls diffuse into the mass of the nitrogen. The pumps are then

[4] An investigation into the design of cathodes and protecting sleeves led the writer to adopt the design illustrated in Fig. 5. A cathode of ordinary design is located within a steel cylinder of such diameter that the distance between the glass wall and the cylinder

started, and the gases liberated, together with the excess nitrogen, are pumped off to a sufficient degree of vacuum. The tube is then sealed and allowed to cool.

After being detached from the pump the tubes show a rather dense yellowish green fluorescence, as distinguished from the bluish green transparent fluorescence generally seen in new gas tubes or hydrogen roentgen ray tubes. When running a tube thus provided and equipped with an adequate regulating substance, a remarkable constancy in the degree of vacuum is discovered. By this procedure all those gases with which metals are capable of entering into chemical combination have been liberated and displaced by the inert nitrogen gas, and, after bringing the tube to the desired degree of vacuum, no further release or adsorption of this gas takes place owing to its inertness as a chemical factor.

is larger than the distance between the cylinder and the cathode. The advantage of this arrangement is that the cathode rays emitted backwards and sideways by the cathode are caught in this cylinder and the energy accumulated on it discharges back to the cathode, i.e., the space between the glass wall and the cylinder must be large enough to prevent the discharge of the *potential* accumulated on this cylinder to the glass wall. It was found that under those conditions no great *potential* accumulates on the cylinder, probably due to the fact that between the impulses this cylinder has an opportunity to discharge over to the cathode. In order to prevent the cathode rays which come from the concave surface from falling on the glass wall and to produce better focusing upon the anticathode target, this cylinder is about 1/16 of an inch beyond the cathode. A small spark gap between the cylinder and the cathode, arranged within the glass holder of the latter, is found advantageous to prevent sparking at the border of the cathode and to prevent the introduction of aluminum vapors into the body of the bulb.

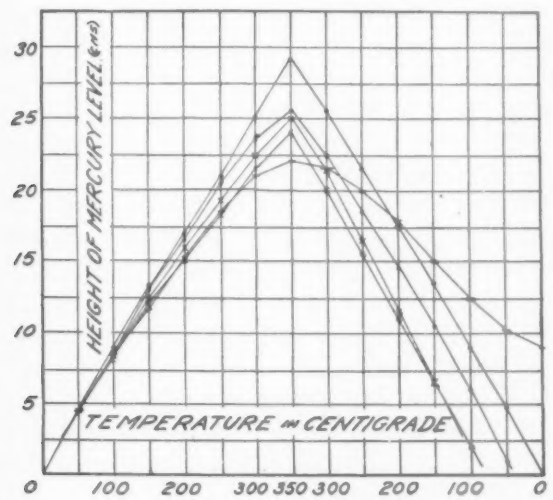

FIG. 5. CURVE 2 SHOWING THE CHANGE OF VOLUME OF HYDROGEN WHEN AT VARIOUS TEMPERATURES.

o Hydrogen without metal.
c Hydrogen in contact with iron.
x Hydrogen in contact with copper.
. Hydrogen in contact with aluminum.
+ Hydrogen in contact with bismuth.

A NEW REGULATING SUBSTANCE.—In order to preserve the advantages gained by producing a homogeneous residuum of inert gas within the tube, the homogeneity of this gas must be preserved. For this purpose the methods and substances hitherto employed for the regulation of the gas pressure of the tube are inadequate. Guided by the experience gained, the preparation of a substance was undertaken which should fulfill the following conditions:

1. The substance, when electric current passes through it, shall liberate pure nitrogen only, without the admixture of any other gases and without the production of metal vapors.

2. The substance must be capable of adsorbing all other gases (oxygen, hydrogen, oxides, etc.) which are chemically more active while adsorbing nitrogen only to a moderate degree.

3. The substance, when electric current is passed through it, must liberate nitrogen only, retaining tenaciously the other gases which are chemically more active.

4. The substance must possess a moderately good electrical conductivity.

5. The vapor pressure or dissociation pressure of the substance must be lower than the gas pressure in the tube.

The nitrides of certain metals, i.e., the chemical combination of a metal with nitrogen, were found to answer these conditions more or less satisfactorily. Thus the nitrides of thorium, aluminum, barium, etc., or a mixture of these, were found to liberate a large amount of gas by the passage of current through them. After considerable ex-

perimenting, a mixture was finally found which, when prepared according to a certain process, answered all the above requirements and proved to be an ideal substance for the regulation and control of the vacuum of tubes.

A New Type of Regulator.—A change in the design of the regulating chamber became necessary to preserve the conditions which the regulating substance must fulfill and to guard against accidental over-reducing of the vacuum. The pattern illustrated in Fig. 6 is the result of a number of experiments with different types of regulators. It consists of a glass cylinder, *a*, narrowed down at the point, *c*; through this narrow

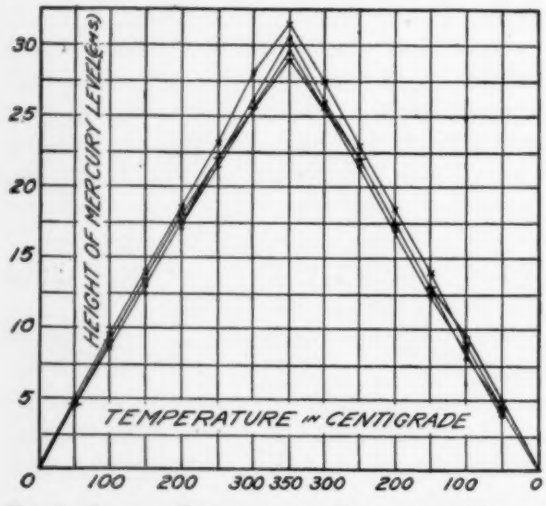

Fig. 6. Curve 3 Showing the Changes of Volume of Nitrogen when at Various Temperatures.

o Nitrogen without metal.
c Nitrogen in contact with iron.
x Nitrogen in contact with copper.
. Nitrogen in contact with aluminum.
+ Nitrogen in contact with bismuth.

part passes an aluminum rod, *l*, which extends a short distance beyond the plug of asbestos wool, *m*, into the regulating substance, *n*, above described. This substance is held in place by a second plug of asbestos wool, *m*. Over this glass cylinder is placed a cylinder of aluminum, *d*, covering about one-third of the regulating substance, and connected to a spiral of aluminum, which, together with the aluminum rod, is attached to the metal cap, *k*. These parts are placed within a glass container, *g*, which is shaped as shown in the drawing.

This arrangement offers the following advantages:

1. When high tension current is applied at the terminal, *k*, if the vacuum of the tube is high, the current will pass through the aluminum wire, *l*, into the regulating substance liberating pure nitrogen in proportion to the amount of current passing.

2. If, on the contrary, the vacuum of the tube is low, current applied to terminal cap, *k*, will not pass through the regulating substance, *n*, but will be switched off through spiral, *s*, to the cylinder, *d*, and will pass on through the vacuum to the positive electrode in the tube.

3. The design of the glass parts is such that the discharge of comparatively heavy currents into this regulator will not cause any local overheating of the glass parts which would result in breakage.

The objects stated under (1) and (2) are made possible by the fact that the low vacuum of the tube provides a path of less resistance for the current when emitted from a metal surface than does the point surrounded by the regulating substance. If, on the contrary, the vacuum is sufficiently high to offer a greater resistance to the current than the regulating substance, the liberation of nitrogen gas and a reduction of the vacuum is the result.

This device, therefore, if the resistance of the two paths of the current is properly balanced, guards against accidental over-reduction of the tube, for at the moment that a certain of degree of vacuum has been obtained by the current passing through the regulating substance, it immediately switches over to the metal cylinder; the latter then assumes a pink glow and no further discharge takes place through the regulating substance, consequently no further liberation of gas ensues.

The proportions of the new tube are such that the tube reduces slightly lower than the practical working vacuum, but no further reduction can be obtained, even with pro-

longed and heavy current passing through the regulator. If slight over-reduction is caused, allowing the tube to stand for about fifteen minutes, then passing a moderate amount of frequently interrupted current through, it will cause the vacuum to increase again to the normal working vacuum.

THE RESULTS OBTAINED.—The properties of the new tube are in marked contrast to those of the ordinary commercial gas-containing roentgen ray tube. A few experiments may illustrate the greater range of application developed in this tube.

One of the new tubes adjusted to 5 milliamperes and 6-inch back-up (64,000 volts) reduction as far as possible is 0.158, i.e., minutes. The anticathode was then red hot, but 5 milliamperes and the back-up of 6 inches were maintained. The same tube adjusted after cooling to a 4-inch back-up and 40 milliamperes could be used to make an exposure of 10 seconds, in steps of one secon1 each, without any change in vacuum; after a lapse of 20 seconds another similar exposure of 10 seconds was made without causing the vacuum to decrease or increase. Such an exposure is more than sufficient to obtain a stereoscopic pair of plates of the heaviest parts of the body since there are 400 milliampere seconds at 65,000 volts available for each exposure.

After cooling, the tube was reduced as far as possible, and, in addition to this, a current of 30 milliamperes was passed through the regulator for 10 seconds. The passing of this extra current did not cause any further reduction; the tube, however, as it was adjusted by balancing the resistances for the current paths in the regulator, was slightly too low in vacuum for average work. It showed a back-up of 2½ inches when passing 40 milliamperes. But, after allowing it to stand for 5 minutes and occasionally passing a few flashes of current of about 20 milliamperes through it, the tube returned to its normal condition, passing 40 milliamperes at 4 inches back-up; in 15 minutes it was so high again, that it had to be reduced.

METHOD OF USING THE NEW TUBE

Since the regulating substance contains a very large amount of chemically combined nitrogen and since, during the intervals between exposures, the gas is adsorbed and released again when the tube is reduced, there is no danger that the regulating substance will become exhausted. For that reason, the tube is pumped to a rather high vacuum so that it can be reduced to any desired degree. Between exposures it always returns to high vacuum.

In case the tube has been over-reduced (the limit of lowest vacuum obtainable by reduction as far as possible is 0.158, *i.e.*, $\frac{\text{back-up}^2}{\text{milliamperes}}$,[5] the vacuum can be increased again either by allowing the tube to stand for a short time, then running the tube with low current, 3-6 milliamperes, or by passing from 20 to 25 milliamperes in very short flashes in rapid succession, i.e., about twenty or thirty flashes of approximately 1/10 of a second each. This flashing probably results in bringing the residual gas into contact with the regulating chemical. Since it is known that the highest gas pressure, when the tube is actuated, is directly behind the anticathode target, the tube should not be heated during this process, but should be run with short flashes for the purpose of concentrating the gas particles in the vincinity of the regulating substance. On the other hand, when normal exposures with about 40 milliamperes are made, the tube does not show this tendency to increase in vacuum because with heavier current there are more ions formed and consequently less accumulation of gas particles behind the anticathode target. When heavy current is passed through the tube, this fact is indicated by the absence of the small blue cloud which is generally shown behind the anticathode target when a moderate amount of current, *i.e.*, 10 or 15 milliamperes, is passed through the tube.

[5] MUTSCHELLER, A. Principles for the Use of Roentgen Ray Tubes. W. E. Co., 1917, p. 12.

The new tube, on account of the flexibility with which the vacuum can be adjusted, offers the great advantage that any desired penetration or volume of tube discharge can easily be obtained. The tube should be reduced and adjusted accurately to the desired degree of vacuum immediately before each exposure is made, because the regulator is sensitive to the action of current, i.e., is readily capable of yielding and readsorbing nitrogen. Due to its large content of gas and the reversible liberation and adsorption of gas, the regulator is practically inexhaustible.

SUMMARY

The principal advantages of this tube can be summed up as follows:

1. Constancy of operation is afforded for prolonged or heavy exposures at any desired degree of vacuum.

2. The tube can be adjusted to any desired degree of vacuum due to the fact that during the interval between exposures the tube returns to the initial condition of high vacuum.

3. The process of "seasoning" is eliminated; a new tube works under exactly the same conditions as an old well-seasoned tube.

4. The design of the tube and regulator are such as to protect the glass parts of the tube from local overheating and to prevent the production of metal vapors from the electrodes.

5. Protection is afforded against the possibility of over-reducing the vacuum by passing discharges through the regulator that are too heavy or too long.

6. In case the reduction has been carried beyond the point of normal vacuum, the tube returns to high vacuum in a short time, so that no inconvenience or further expenditure is brought about by having over-reduced tubes sent to the tube maker for re-exhausting.

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TWENTY-FIRST ANNUAL MEETING

The Twenty-first Annual Meeting of The American Roentgen Ray Society will be held at Rochester, Minn., and Minneapolis, Minn., September 14, 15, 16 and 17, 1920; at Rochester on the 14th, at Minneapolis on the 15th, 16th and 17th.

Further details and advance information concerning the meeting will appear in these columns from month to month.

Minneapolis headquarters, Curtis Hotel.

DR. JOHN A. LEE

The death of Dr. John A. Lee at his home in Brooklyn, N. Y., on April 4, 1920, adds one more to the list of those pioneers in the use of the roentgen rays who have given up their lives as a result of injuries sustained before the dangers of the rays were recognized. Dr. Lee began this work in 1889, operating the first hospital equipment in Brooklyn. Like most of the early workers, he did much fluoroscopic work without protection, and by 1904 he had to abandon the work because of the injuries he had sustained, involving chiefly his left hand.

Having always had a leaning to surgery, he then devoted himself to this branch of medicine, in which he was highly successful. At the time of his death, he was attending surgeon to the St. Mary's and Kingston Avenue Hospitals, and consulting surgeon to several other institutions. He was a prominent member of the county and state medical societies, and was last December elected President of the Medical Society of the County of Kings.

Dr. Lee was born in New Britain, Connecticut, in 1873, and prepared for college at the New Britain High School. He was graduated from Yale College in 1895, and the Yale Medical School in 1897.

During the recent war he organized a naval hospital unit which served on the hospital ship *Comfort*. He was chief of the surgical service on this ship with the rank of Lieut. Commander, and shortly after going on the reserve list, was made Commander.

His medical history is unusual in that in 1908 he was operated on for axillary tumor, which proved to be carcinoma. In 1919, he was again compelled to submit to surgery, because of an axillary tumor, which proved to be sarcoma, and this was soon followed by metastases in the lungs.

JOHN G. WILLIAMS.

ANNUAL MEETING OF THE OMAHA ROENTGEN SOCIETY

The Annual Meeting of the Omaha Roentgen Society was held at the Hotel Fontenelle, March 27, 1920.

Clinics were held at the University of Nebraska and at St. Joseph's Hospital.

The following papers were read:

The Treatment of Cancer by the Roentgen Ray, Dr. A. P. Overgaard, Omaha.

Dr. W. N. Anderson of Omaha gave a few introductory remarks explaining the moving picture films which had been furnished by the United States Government demonstrating the principles of physical diagnosis as used in instructing the members of the medical corps during their army training.

Oral Infection in Its Relation to Systemic Diseases, Dr. Wm. W. Duke, Kansas City.

The Clinical Application of Peritoneoscopy, Dr. B. H. Orndorff, Chicago.

Dr. E. W. Rowe, of Lincoln, Nebraska, read a paper on Tuberculosis of the Kidney from the Roentgen Standpoint.

Dr. Harry A. Everett, of Lincoln, Nebraska, read a paper on the *X*-ray from a Surgical Aspect.

Dr. E. H. Skinner, of Kansas City, gave a talk on Management of Severe Malignancies of the Throat and Neck.

Dr. R. D. Carman, of Rochester, Minnesota, read a paper on Tuberculous Colitis.

Dr. J. B. Potts, of Omaha, Nebraska, read a paper on Maxillary Sinus Infection Secondary to Periapical Infection of the First Upper Molar and with Polypi.

During the luncheon, which was served at the Omaha Chamber of Commerce, Dr. Joseph Colt Bloodgood, of Baltimore, spoke of the Things that a Layman should know about the *X*-Ray.

A banquet was held in the evening, and Dr. Bloodgood gave an illustrated talk on The Roentgent Diagnosis of Bone Tumors. This talk was based upon pathological material secured at the Johns Hopkins Hospital during the past twenty-five years. It was logical, very comprehensive and entertaining. The doctor's research work in this line is unsurpassed and has opened up many new diagnostic points in the matter of bone disease. His reclassification of the names of bone tumors is admirable, greatly simplifying the nomenclature and making it much easier for the student to grasp the principles of the pathology.

The plate exhibit was well prepared and much interesting pathology was shown. The manufacturer's exhibit was as large as is usually found at a national medical meeting.

ANNOUNCEMENT

The Annual Meeting of the Western Electro-Therapeutic Association will be held in Kansas City, Mo., on May 27-28, 1920.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

TRANSLATIONS & ABSTRACTS

DIEMER, F. E., and CRAMER, I. H. Roentgenological Determination of Pulmonary Tuberculosis. (*Am. J. M. Sc.*, Vol. CLVIII, No. 6, Dec., 1919.)

In plate interpretation, every shadow, configuration and position must be understood and carefully studied. The visibility of the broncho-vesicular tree must be appreciated for height, age, weight and occupation. The differentiation between peribronchial infiltration and thickening must be understood. The exact difference of degree of illumination and radiability is very important.

Abnormal configuration of the heart silhouette suggests valvular disease, which might account for abnormal lung shadows. Circumscribed areas resembling calcification are seen distributed throughout, particularly the lower quadrants, the result of dilated vessels in mitral disease.

Position and configuration of the diaphragm convey much information. The degree of parenchymal involvement is determined by the diaphragmatic position in deep inspiration. Previous pneumonias often leave pleurodiaphragmatic adhesions.

The condition of the hilus is extremely important. Infiltration, calcification or exaggeration results both from pulmonary infection and from abdominal infection, and the differentiation must be made from the general and minute lung picture.

The location of calcification areas throughout the lung fields is very suggestive. Diffused distribution suggests healed disseminated tuberculosis. A few areas in the lower quadrants designate the location of the primary tubercle, while those in the upper quadrants are more significant of quiescent, inactive or chronic active tuberculosis. The configuration and radiability of calcification areas suggest the activity of the process. Dense areas, undoubtedly lime salts, that are not discrete and where borders are not clear cut but blend gradually with the surrounding lung tissue, particularly if the center presents a delicate mottling (suggesting that the interstitial tissues remain intact), indicate that the process is active and the caseation area has not completely become calcified.

There are many pathological conditions which involve the lower quadrants but very few which involve the upper quadrants. If abnormal shadows are found in the upper quadrants the first thought is tuberculosis, although the pneumonias and various other conditions (which do not present the typical tubercular shadows) must be differentiated. If abnormal shadows are seen in the lower quadrants a non-tuberculous process is suspected.

CONCLUSIONS.—1. The definite determination of pulmonary tuberculosis by means of roentgen study alone in practically every stage is possible. The stage and the activity of the process are not as definitely established by roentgen study alone as by physical examination alone, but a combination of both is decidedly more reliable than either alone.

2. *The stage of an excavation is readily determined.*

3. *There are distinct roentgenological pathognomonic indications of pulmonary tuberculosis.*

4. *The exact involvement is more readily made out by roentgen study. Much assistance is furnished the clinician in regard to prognosis.*

The value of thorough roentgen study of the chest in tuberculosis varies slightly in different stages and forms of the disease.

1. In the incipient stage the roentgen study is of undoubted value, definite haziness, peribronchial infiltration and a marked degree of lessened illumination upon coughing or deep inspiration being determined on plate and screen. These roentgen indications appear as soon as does the clinical evidence.

In the cortical type the clinical findings are exaggerated while the roentgen evidence is not pronounced, but in the peribronchial and bronchopneumonic tuberculosis the findings are reversed. In these latter types there is apparently a hilus tuberculosis and the infection extends bronchogenetically, usually along the course of the vertebral, first intercostal and second intercostal bronchi.

2. After fibrous infiltration takes place the roentgen indications are almost pathognomonic, particularly for the disease, but also for activity to a slightly lesser degree. Even be-

fore mediastinal retraction appears the evidence of fibrosis is apparent because of the extensive bronchovesicular thickening, the delicate strand-like shadows and the further decrease in radiability. After organization of the fibrous process, with more or less retraction and the appearance of compensatory emphysema, the diagnosis is more readily reached; but activity is less easily determined. At this stage the process is very liable to become quiescent. The physical findings are then very indefinite indeed.

3. The caseation areas are not definitely made out, but after calcification takes place, whether with marked or little fibrosis, the diagnosis is definite for tuberculosis and the degree of activity is suspected.

4. (*a*) *The acute cavity does not present a definite, distinct capsule; its configuration is not oval or circumscribed but more likely to be irregular; the radiability of its center is the same or less than the surrounding parenchymal shadows; it does not illuminate upon the patient coughing and there is no distinct drainage sinus leading toward the hilus.*

(b) The subacute cavity begins to assume a definite circumscribed form; its capsule is readily seen, but is as yet not as definitely marked as in the chronic cavity; it usually contains a small quantity of fluid in its dependent portion, which indicates that drainage has not been perfected; above the fluid level the radiability is increased, indicating the presence of air. As yet the cavity does not illuminate upon coughing nor does the drainage sinus present as distinctly as later.

(c) The chronic cavity presents distinctly a fibrous capsule; it is oval or circular in shape, flat or spherical in configuration; it contains no fluid if the patient is examined late in the morning or in the afternoon; it illuminates brilliantly upon coughing and the thickened drainage sinus is readily made out.

(d) Healed cavities are not often seen; they present a very marked, thick capsule; contain no fluid; are very small in area and illuminate only slightly upon coughing. The drainage sinus is narrow, but its borders are very sharply outlined, indicating that no perisinus parenchymal involvement is present.

5. In the deep peribronchial type of tuberculosis, without parenchymal involvement, a distinct circumscribed peribronchial thickening will give way to an indication of peribronchial infiltration, and the bronchovesicular tree then presents a fuzzy rather than sharply delimited appearance. Extension of the process is then rapid, and there is an extreme lack of illumination on the plate, presenting a delicately mottled increase in density.

6. In massive hilus tuberculosis the roentgenologist is on a par with the clinician; its existence and activity can only be guessed. Before calcification no definite indications are seen, either by screen or plate; after lime salt deposit, visualization of the area is obtained and quiescence suspected if the calcification is uniform in radiability and sharply demarcated, and *vice versa.*

7. In disseminated tuberculosis the lung picture presents nothing definite unless healing takes place, when many small areas of calcification are seen distributed throughout both lung fields, the greater number in the lower quadrants.

8. Probably all types of pulmonary tuberculosis can be classed, strictly speaking, as a true bronchopneumonia during a certain stage, but the roentgenological presentation of an acute tuberculous bronchopneumonia, in which the parenchymal involvement is peribronchial, superimposed upon a chronic fibrous process, is distinctive and typical. True, it is impossible by any means to differentiate the acute pneumonic process, especially if the tubercle bacillus is found in the sputum with an abundance of streptococcus, particularly the hemolytic type. Streptococcus infection of the lung parenchyma often involves the upper quadrants, both unilateral and bilateral, and is extremely difficult to distinguish from a tuberculous infection.

An old quiescent lesion which becomes active following measles, pneumonia, etc., is inclined to involve either both lungs in their entirety, the opposite lung only, especially in its lower quadrant, or the lower quadrant of the same lung in which the lesion is located.

Calcification areas, wherever located in the lung, in the vast majority of cases indicate, that at some time there has been an active tuberculous process, but those of the lower quadrants are rather incidental, as healing usually takes place and the process stops at the bronchial glands. In the upper quadrants they indicate that the patient has a true, dangerous tuberculous infection which is either healed, quiescent or more or less active. If in

addition there are indications of fibrosis, with no emphysema and little or no mediastinal or chest-wall retraction, activity is indicated. If clear, irregular emphysematous areas are interspersed, with more or less retraction, and the calcification areas are clear-cut and uniformly dense, the process is probably quiescent, chronic-inactive or healed. Differentiation from lues, the fungi infections and the pneumonias can be made without difficulty, but only after observing many cases.

Excavations are unmistakable if studied by both plates and screen. Activity is at once established, the differentiation from non-tuberculous lung abcesses presenting no very great difficulty. The tuberculous cavities, except in a very small percentage, are found high in the upper quadrants and are often multiple or bilateral, while lung abscesses are practically always found in the body of a lobe and seldom multiple or bilateral. Pulmonary abscesses are either filled with broken-down, semi-solid tissue or with pus, the patients not living sufficient time for but few of them to establish drainage or air to collect above the fluid level. Lung abscesses invariably in a few days present a collection of air above the fluid level. The same is true of tuberculous cavities, but the surrounding lung shows unmistakable evidence of peribronchial thickening, fibrosis and other signs of tuberculosis, depending upon the stage of the process. A non-tuberculous cavity tends to heal if adequate drainage is established, and is seldom seen when empty, while the tuberculous cavity does not as often completely heal and is usually empty.

Other conditions to a lesser degree pathognomonic are as follows: Fibrosis, retraction of the trachea, mediastinal contents, heart and chest wall, a decided lack of illumination of one or both upper quadrants on deep inspiration or coughing before the screen, and a lessened radiability, either uniform or delicately mottled on the plate; abnormal presentation in the upper quadrants if there is a hanging "dropped" or very small heart silhouette; or if the diaphragm on the corresponding side is in partial expiratory position or its excursion is impaired on deep inspiration. Any abnormality found in the upper quadrants should prompt the roentgenologist to suggest the probability of tuberculosis unless definite indications of another process are certain.

WEBSTER W. BELDEN.

MOLYNEAUX, E. S. Radium in the Treatment of Tuberculous Adenitis. (*Brit. M. J.*, November 29, 1919.)

This article reports a series of from twenty to thirty cases of tuberculous adenitis treated with radium with marked success. Nodes at all stages of the disease were in the series and in all of them the swelling disappeared leaving no scar unless a sinus had been present at the beginning of the treatment. Ulceration did not occur in any case. Fifteen milligrams of radium bromide spread over an applicator one and one-fourth inches in diameter, screened by one millimeter of silver was strapped over the area to be treated for ten hours. Two applications a week were usually employed. After a week or ten days the swelling was seen to begin to grow smaller and at the end of a few weeks nothing but fibrous nodules were left to show the place of the old lesion. In some of the cases the cure has lasted for four or five years.

ESPINOLA, RAFAEL. Radiotherapy in Surgical Tuberculosis of Children. (*Semana Méd.*, October 30, 1919.)

The author is convinced that radiotherapy, in the perfected technic of the present day, is the treatment of election in surgical tuberculosis, more especially in the larger cities where the benefits of fresh air, sunshine, and proper food are often not available. The rapidity of resolution of glandular masses is in direct relation to the dose of the rays. Cold abscesses, the pus of caseous suppurating adenitis, should be evacuated by simple incision followed by intensive radiation. The dose and length of session of the *x*-ray treatment can be adapted to the intensity of the bacillary infection; high virulence calling for large doses, low virulence for small doses. It is possible to give daily treatments for fifteen days without producing a dermatitis, providing the rays are filtered and of short wave length. There is no advantage in intensive radiation of cutaneous tuberculosis in the stage of reparation as this destroys the new cells which form the cicatrical tissue. It is advisable to employ, in conjunction, general hygiene, ample nourishment, heliotherapy, fresh air, and the proper climate to defend the system against the tubercle bac-

illus, and to prevent the formation of new foci. Surgery, in most cases of surgical tuberculosis in children, should be looked upon as a method of secondary importance; scientifically practiced, roentgenotherapy either alone or associated with other phases of treatment is quite capable of curing the so-called surgical affections.

DIMIER ET BERGONIE. Recherche du filaire de Médine par la radiographie (Guinea-worm Revealed by *X*-rays). (*Archiv. d'électr. méd.*, 1918, Vol. 26, 337.)

Usually animal parasites are so transparent to *x*-rays that their existence in the body is not revealed by these means: when calcified, however, they may be recognized. The authors found evidences of Guinea-worms in several wounded soldiers from Guinea and Senegal, in whom the existence of an abscess called for treatment. Apart from radiological examination the abscess might have been suspected to depend upon some military injury. The entozoa were always found in the usual situation, viz., leg or lower part of thigh, and the *x*-ray examination showed a tortuous coiled arrangement of the worm.

W. S. L.-B.

KEY UND AKERLUND. Fall von verkalktem Aneurysma in der Arteria renalis (Calcified Aneurysm of the Renal Artery). (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1918, Vol. 25, 551.)

A somewhat laborious description of what appears to be a condition hitherto undescribed in radiological literature. The aneurysm was about the size of a hazelnut, its existence at the hilus of the kidney was recognized under the *x*-rays, an operation was done on the supposition that the case was one of renal stone, and the gush of arterial blood which took place and necessitated ligature of the artery and extirpation of the kidney afforded the first indication of the nature of the mass. Recognition of the condition as a source of possible error in diagnosis is desirable, but reduction of the paper to a quarter of its length would have been advantageous.

W. S. L.-B.